Benthic TMDL Development for Popes Head Creek, Virginia

Submitted to

Virginia Department of Environmental Quality

Prepared by

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. Popes Head Creek was initially listed on Virginia's 1998 Section 303(d) List of Impaired Waters (DEQ, 1998) and was subsequently included on Virginia's 2002 Section 303(d) List of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2002; 2004) because of violations of the water quality standards for fecal coliform bacteria and the General Standard (benthic impairment). This report addresses the benthic impairment; the bacteria impairment will be addressed in a separate TMDL report. Biological assessments conducted at DEQ monitoring station 1APOE002.00, located at the intersection of Popes Head Creek and Route 645, indicate an impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing.

Popes Head Creek is located in the northern region of Virginia, and is a tributary of Bull Run in the Occoquan Reservoir drainage. The headwaters of Popes Head Creek originate in the City of Fairfax; the remainder of the watershed is located in Fairfax County, Virginia.

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Biological assessments conducted at DEQ monitoring station 1APOE002.00, located at the intersection of Popes Head Creek and Route 645, indicate an impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing. The impaired benthic segment of Popes Head Creek (VAN-A23R-02) is 4.92 miles in length, beginning at the confluence of Piney Branch and Popes Head Creek, and ending at the confluence of Popes Head Creek with Bull Run. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

Watershed Characterization and Environmental Monitoring

The Popes Head Creek watershed is approximately 12,120 acres. Developed lands (56.9%), forested lands (36.9%), and agricultural lands (3.5%) represent the dominant land use types in the watershed. There are three general soil associations present in the Popes Head Creek watershed; Buckhall-Occoquan-Meadowville, Jackland-Waxpool-Catlett, and Manor-Glenelg-Chester. The majority (50.6%) of soils in the watershed are comprised of the Manor-Glenelg-Chester soils association.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) impacting the benthic community of Popes Head Creek. Environmental monitoring efforts in the Popes Head Creek watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, and toxicity testing. Monitoring efforts have been conducted by the Virginia Department of Environmental Quality (VADEQ), Fairfax County Stormwater Planning Division, and Audubon Naturalist Society (ANS), a citizen monitoring group. Biological monitoring has been conducted by DEQ at station 1APOE002.00 on the biologically impaired segment of Popes Head Creek, and DEQ has collected ambient water quality data at five additional stations in the watershed. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the wastewater treatment facilities in the watershed.

Stressor Identification

Assessment of the primary stressor contributing to biological impairment in Popes Head Creek was based on evaluations of candidate stressors that can potentially impact the river. The identification of the most probable cause of biological impairment in the Popes Head Creek was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed.

Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with the conclusive data linking them to the poorer benthic community.

The data and analysis presented in this report indicated that dissolved oxygen, temperature, and pH, in the biologically impaired segment of Popes Head Creek are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Concentrations of metals and organic chemicals were generally low or below analytical detection limits and are classified as non-stressors. Toxicity testing suggested the presence of potential toxicity, however, the data are inconclusive to show a direct impact on the benthic community. Consequently, instream toxicity is considered as a possible stressor in the impaired segment of the Popes Head Creek watershed.

Based on the evidence and data discussed in Section 4.0, the Stressor Identification Analysis, sedimentation caused by higher runoff flows has been identified as a primary stressor impacting benthic invertebrates in the biologically impaired segments of the Popes Head Creek watershed. Habitat scores indicate decreased habitat quality in the impaired segments because of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, stream bank erosion, and sediment loss from habitat degradation associated with urbanization.

The interrelation between sedimentation, higher runoff flows, and habitat alteration, allows a TMDL for sediments to address habitat degradation as well as increased urban runoff. Improvement of the benthic community in the biologically impaired segment of the Popes Head Creek watershed is dependent upon reducing sediment loadings through stormwater control, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river.

To address these issues, a sediment TMDL will be developed for the biologically impaired segment of the Popes Head Creek watershed.

Reference Watershed Approach

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for Popes Head Creek.

The Goose Creek watershed draining to the DEQ biomonitoring station at Goose Creek river mile 22.44 (1AGOO022.44) was selected as the reference watershed for Popes Head Creek benthic TMDL development. Reduction of sediment loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for Popes Head Creek.

Sediment Loading Determination

Sediment sources within the Popes Head Creek watershed include both point and non-point sources. Point sources include solids loading from permitted discharge facilities and land-based loading from areas covered by municipal separate storm sewer system (MS4) permits. Non-point sources include sediment derived from the erosion of lands present throughout the watershed and the erosion of stream banks.

Sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Popes Head Creek. Sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1994 to 2004 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of Popes Head Creek. Average annual sediment loads were computed for each land source based on the 10 year simulation period. In addition, average annual sediment loads from instream bank erosion, point sources, and MS4 permitted areas were determined. Point source loadings were computed based on the permitted discharge loading rate for total suspended solids. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al (2003). An area-weighted method was used to determine the land-based load attributed to MS4s present in the watershed.

Under the reference watershed approach, the TMDL endpoint is based on sediment loadings for the reference watershed. Sediment loadings computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Sediment TMDL allocations for Popes Head Creek were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:
TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of sediment loadings. An explicit margin of safety of 10% was used for the Popes Head Creek benthic TMDL.

Since there are not any known point sources present within this watershed, 1% of the TMDL was reserved to account for future growth and potential point sources within the watershed. Load allocations for non-point sources and wasteload allocations for the MS4s were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions.

There are currently no individually permitted point source facilities in the Popes Head Creek impaired watershed. The MS4 permits state that the City of Fairfax, Fairfax County, Fairfax County Public Schools, and VDOT urban areas which hold MS4s are permitted to discharge into the Popes Head Creek impaired watershed. However, stormwater permits typically do not have numeric limits for sediment. To separate sediment loading attributed to the MS4s from other land-based sediment loading, an area weighted sediment load was determined for the MS4s, in which the percentage of sediment loading from each source area attributed to the MS4s was proportional to the percentage of that source area in the Popes Head Creek impaired watershed covered by the various MS4 permits. The MS4 areas located within the watershed are shown in **Table E-1**. Additionally, stormwater runoff from MS4s results in increased stream bank erosion. Bank erosion resulting from MS4 stormwater runoff and bank erosion resulting from overland runoff were also separated using an area weighted approach, in which the percentage of sediment loading from bank erosion attributed to the MS4 was proportional to the percentage of the Popes Head Creek impaired watershed covered by the MS4 permits. Since 12,097.5 acres of the 12,120 total acres in the Popes Head Creek impaired watershed are covered by MS4 permits, 99.8 percent of the sediment load from instream erosion was attributed to the MS4s. Sediment from other land sources in the watershed and the remainder of the bank erosion sediment load were attributed to the land-based load.

Table E-1: MS4 Permits located in Popes Head Creek Watershed

MS4 Permit Number	MS4 Permit Holder	MS4 Locality	Acres
VA0088587	Fairfax County	Fairfax County	11,926.0
VAR040104	Fairfax County Public Schools		
VAR040062	VDOT Urban Area		
VAR040064	City of Fairfax	City of Fairfax	171.5
VAR040062	VDOT Urban Area		
Total			**12,097.5**

Load allocations for non-point sources not covered under the MS4 permits were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 28.2%, the sediment TMDL endpoint is achieved. This reduction corresponds to a 27.75% overall reduction when including all land-based loads (e.g., forest has a zero percent reduction). The existing and allocated sediment loads for all sources in the Popes Head Creek impaired watershed are presented in **Table E-2**. In addition, the necessary percent reduction is shown for each source.

TableE-2: Summary of Existing and Allocated Sediment Loads for Popes Head Creek Watershed

Source	Land Use Type	Existing Load (tons/yr)	Allocated Load (tons/yr)	Percent Reduction
Nonpoint Source	Deciduous Forest	0.0300	0.0300	0.0
	Evergreen Forest	0.0030	0.0030	0.0
	Mixed Forest	0.0038	0.0038	0.0
	Pasture/Hay	0.0914	0.0656	28.2
	Row Crop	0.0153	0.0110	28.2
	Quarries Strip Mine	0.0000	0.0000	0.0
	Low Intensity Residential	0.0041	0.0030	28.2
	Medium High Intensity	0.0489	0.0351	28.2
	Commercial/Industrial	0.0232	0.0166	28.2
	Institutional	0.0075	0.0054	28.2
	Urban Recreational Grass	0.0001	0.0001	28.2
	Instream Erosion	2.1115	1.5163	28.2
Permitted Facilities	Individual VPDES Permits	0.0	15.8*	0.0
	General Permits-Domestic Sewage	0.1369	0.1369	0
	Stormwater Permits-Construction	13.14	9.46	28.2
MS4	Nonpoint Source	224.79	160.8#	28.42#
	Instream Erosion	1,968.39	1,408.0#	28.47#
	Total	**2,208.8**	**1,596.0**	**27.75**

(*)A one percent (1%) of the MS4s allocated loads (NPS + instream erosion) was set aside to account for future growth and the potential change in land-use from rural/open space to urban.
(#) the MS4 loads (NPS and instream erosion) are reduced by 15.8 tons/year (1% set aside to accommodate for future growth) in order to met the TMDL target

The total load and wasteload allocations and margin of safety for the Popes Head Creek are summarized in **Table E-3**. Recommended allocations for each source in the watershed are provided in **Table E-2**. For this TMDL a 1 percent of the total allocated MS4 load (15.8 tons/year) is set aside for future growth.

Table E-3: Sediment TMDL for Popes Head Creek (tons/year)

TMDL (tons/yr)	Load Allocation (tons/yr)	Wasteload Allocation (Point Source + MS4s) (tons/yr)	Margin of Safety (10%) (tons/yr)
1,773.1	**1.7**	**1594.2**	**177.3**

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

Public Participation

The development of the Popes Head Creek benthic TMDL would not have been possible without public participation. Public meetings were held on March 30, 2005 at the Sully District Governmental Center in Chantilly, Virginia, on April 5, 2005, at the Pennington School in Manassas, on December 14, 2005, at the Sully District Governmental Center in Chantilly, Virginia, and on March 15, 2006 at the Central Community Library in Manassas, VA to discuss each step of the Popes Head Creek TMDL. Copies of the presentation and the draft TMDL report executive summary were available for public distribution at each meeting. Also, each meeting was public noticed in *The Virginia Register of Regulations.*

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List of Acronyms

ANS	Audubon Naturalist Society
BMP	Best Management Practices
BNR	Biological Nutrient Removal
COD	Chemical Oxygen Demand
DCR	Department of Conservation and Recreation
DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-ethane
DDT	Dichloro-diphenyl-trichloroethane
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DMR	Discharge Monitoring Report
DMME	Department of Mines, Minerals, and Energy
DO	Dissolved Oxygen
EPA	Environmental Protection Agency (discrepancy, also use USEPA) 2-7
GIS	Geographic Information System
GWLF	Generalized Watershed Loading Functions
IP	Implementation Plan
K	Soil Erodibility
LA	Load Allocation
LID	Low Impact Development
LS	Length-slope
MOS	Margin of Safety
MOU	Memorandum of Understanding

MS4	Municipal Separate Storm Sewer
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NVRC	Northern Virginia Regional Commission
OWML	Occoquan Watershed Monitoring Laboratory
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
RBPII	Rapid Bioassessment Protocol II
SCI	Stream Condition Index
SPD	Stormwater Planning Division
STATSGO	State Soil Geographic
SWCB	State Water Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSI	Tissue-Screening Value
TSS	Total Suspended Solids
TV	Tissue Value
VADEQ	Virginia Department of Environmental Quality
VA SOS	Virginia Save Our Streams Program
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program Permits
UAA	Use Attainability Analysis
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WET	Whole Effluent Toxicity
WLA	Wasteload Allocation
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQMP	Water Quality Management Plan

1.0 Introduction

Total Maximum Daily Load (TMDL) development for biological impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow streams to attain their designated uses. The identification of the pollutant(s), or *stressor(s),* responsible for the impaired biological communities is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the waterbody to comply with Virginia's water quality standards. This report details the steps used to identify and characterize the stressor(s) responsible for biological impairments in Popes Head Creek, Virginia. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. In the subsequent sections of this report, watershed and environmental monitoring data collected on Popes Head Creek are presented and discussed. Stressors which may be impacting the creek are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic invertebrate communities in the creek are identified. A TMDL will be developed for the stressor identified as the primary source of biological impairment in Popes Head Creek.

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and

Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and implement a more effective TMDL process. DEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. DEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA, passed by the Virginia General Assembly in 1997), and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (DEQ, 2001).

As required by the Clean Water Act and WQMIRA, DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (DEQ, 2001). DEQ also solicits participation and comments from watershed stakeholders and the public throughout the TMDL process. Once TMDLs have been developed and the public comment period has been completed, the TMDLs are submitted to EPA for approval.

1.2 Impairment Listing

Popes Head Creek was initially listed on Virginia's 1998 Section 303(d) List of Impaired Waters (DEQ, 1998) and was subsequently included on Virginia's 2002 Section 303(d) List of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2002; 2004) because of violations of the water quality standards for fecal coliform bacteria and the General Standard (benthic impairment). This report addresses the benthic impairment; the bacteria impairment will be addressed in a separate TMDL report. Biological assessments conducted at DEQ monitoring station

1APOE002.00, located at the intersection of Popes Head Creek and Route 645, indicate an impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing.

Popes Head Creek is located in the northern region of Virginia, and is a tributary of Bull Run in the Occoquan Reservoir drainage. The headwaters of Popes Head Creek originate in the City of Fairfax; the remainder of the watershed is located in Fairfax County, Virginia. The impaired benthic segment of Popes Head Creek (VAN-A23R-02) is 4.92 miles in length, beginning at the confluence of Piney Branch and Popes Head Creek, and ending at the confluence of Popes Head Creek with Bull Run. **Figure 1-1** depicts the impaired segment of Popes Head Creek, as well as the delineated watershed boundary.

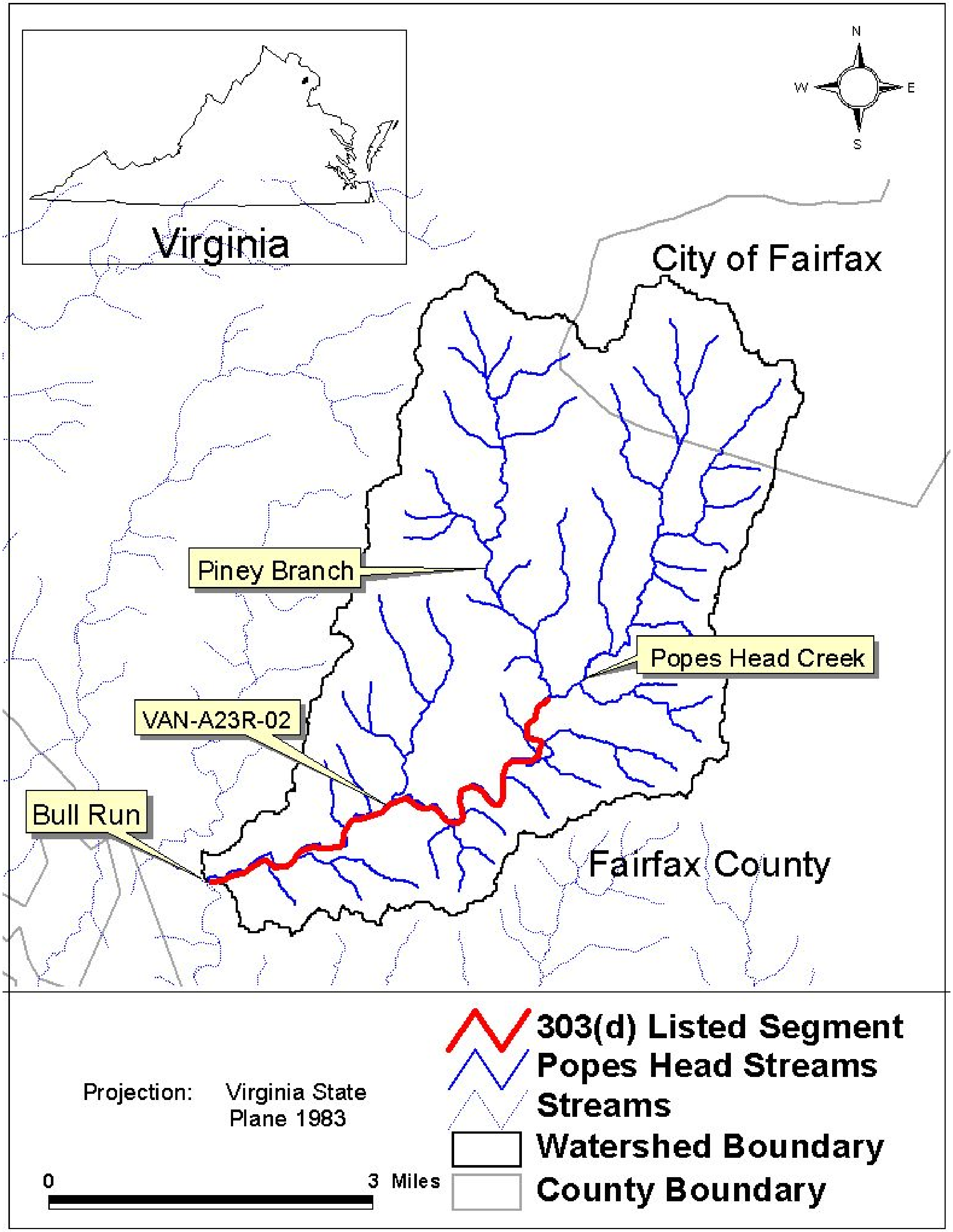

Figure 1-1: Popes Head Creek Impaired Segment and Delineated Watershed

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *water quality standards* "means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

The listed segment defined in Section 1.2 does not support the propagation and growth of aquatic life in Popes Head Creek, based on the biological assessment surveys conducted on the creek.

1.3.2 Water Quality Criteria

The General Standard defined in Virginia Water Quality Standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standard states:

> *"All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

The biological assessments conducted on Popes Head Creek indicate that some pollutant(s) are interfering with attainment of the General Standard, as impaired invertebrate communities have been observed in the listed segment of the creek. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

2.0 Watershed Characterization

The physical conditions of Popes Head Creek were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the listed segment of the creek. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. In particular, physical watershed features such as topography, soils types, and land use conditions were characterized. In addition, the number and location of permitted facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the Popes Head Creek watershed that may be contributing to the benthic impairment were analyzed using GIS coverages developed for the area. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

2.1.1 Watershed Location and Boundary

The headwaters of the Popes Head Creek watershed flow through the western section of the City of Fairfax; the remainder of the Popes Head Creek watershed is located in Fairfax County, Virginia (**Figure 2-1**). The watershed is approximately 12,119 acres or 18.9 square miles. The impaired segment of Popes Head Creek is located entirely within Fairfax County.

2.1.2 Stream Network

The stream network for the Popes Head Creek watershed was obtained from the USGS National Hydrography Dataset (NHD). The stream network and benthic impairment segment are presented in **Figure 2-1**.

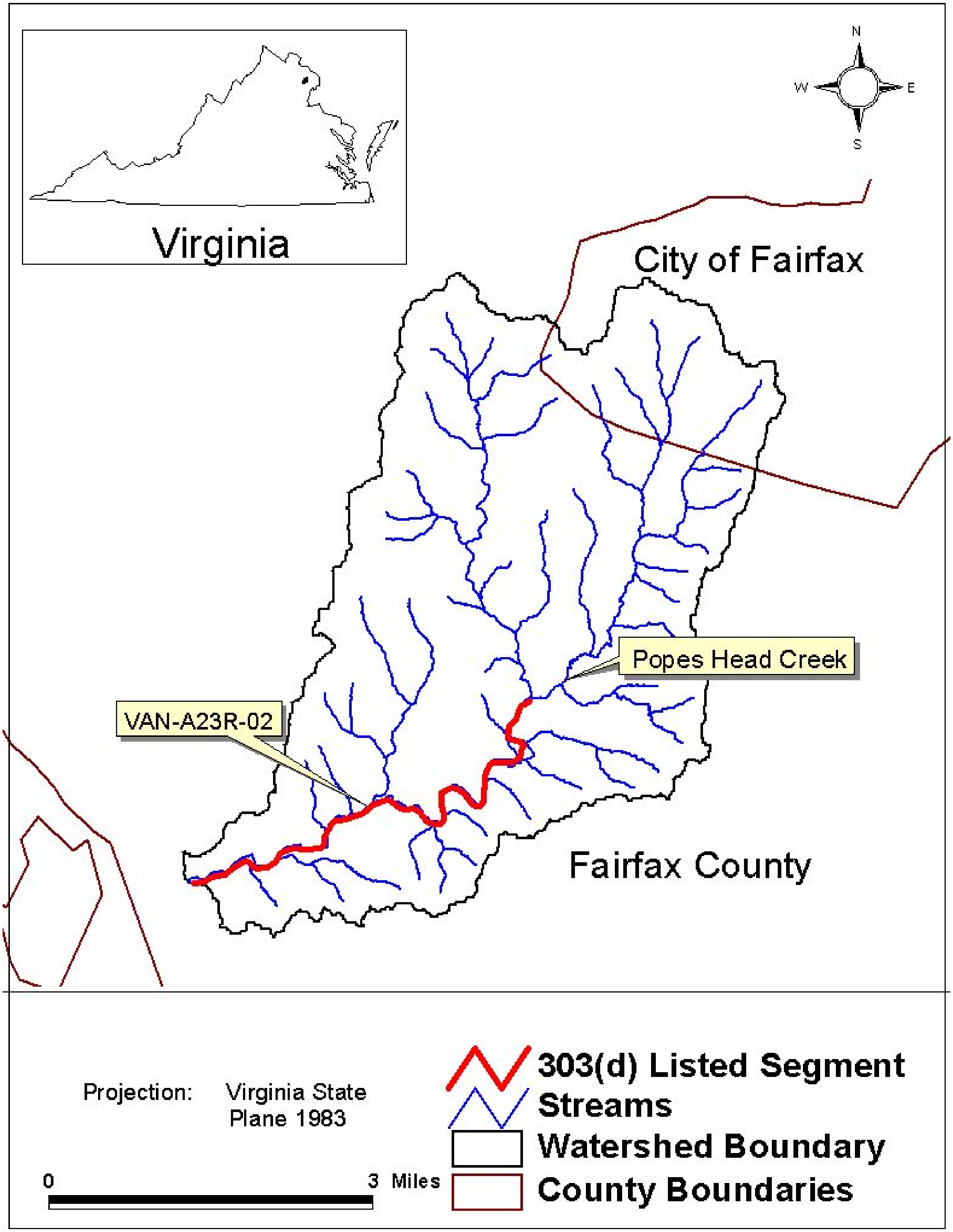

Figure 2-1: Stream Network for the Popes Head Creek Watershed

2.1.3 Topography

A digital elevation model (DEM) was used to characterize topography in the watershed. DEM data obtained from BASINS show that elevation in the watershed ranges from approximately 117 to 444 feet above mean sea level, with an average elevation of 309 feet above mean sea level.

2.1.4 Soils

The Popes Head Creek watershed soil characterization was based on the NRCS State Soil Geographic (STATSGO) Database for Virginia. There are three general soil associations present in the Popes Head Creek watershed; Buckhall-Occoquan-Meadowville, Jackland-Waxpool-Catlett, and Manor-Glenelg-Chester. The majority of soils in the watershed are comprised of the Manor-Glenelg-Chester soils association. The distribution of soils in the Popes Head Creek watershed, along with the hydrologic soil groups of each of the soils associations, is presented in **Table 2-1**.

Table 2-1: Soil Types in the Popes Head Creek Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA013	Buckhall-Occoquan-Meadowville	31.1	B
VA022	Jackland-Waxpool-Catlett	18.3	B/C/D
VA071	Manor-Glenelg-Chester	50.6	B/C/D

Source: State Soil Geographic (STATSGO) Database for Virginia

Hydrologic soil groups represent the different levels of soil infiltration capacity. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the groundwater system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the groundwater, resulting in more rainfall delivered to surface waters in the form of runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

2.1.5 Land Use

The land use characterization for the Popes Head Creek watershed was based on land cover data from both the Northern Virginia Regional Commission (NVRC) 2000 Land Use Dataset, and the 1992 USGS National Land Cover Data (NLCD). The NVRC dataset was the most recent available land use dataset, and was also utilized in order to be consistent with other ongoing modeling efforts within the Occoquan Reservoir basin. However, the NVRC dataset does not specify forested or open (i.e., pasture) lands; therefore, the NLCD dataset was used to fill in the remaining areas. The distribution of land uses in the Popes Head Creek watershed, by land area and percentage, is presented in **Table 2-3**. Developed lands (56.9%), forested lands (36.9%), and agricultural lands (3.5%) represent the dominant land use types in the watershed. It should be noted that the majority of the developed lands present in the Popes Head Creek watershed are zoned for 2-acre or 4-acre lots, and thus are comprised of less impervious surfaces than typically observed developed areas. **Figure 2-2** displays a map of the land uses within the watershed.

Table 2-3: Popes Head Creek Watershed Land Use Distribution

General Land Use Category	Specific Land Use Type	Acres	Percent of Watershed	Total Percent
Water/ Wetlands	Open Water	11.0	0.1%	1.3%
	Woody Wetlands	4.9	0.0%	
	Emergent Herbaceous Wetlands	141.1	1.2%	
Developed	Low Intensity Residential	5,035.2	41.5%	57.6%
	Medium/High Intensity Residential	1,420.3	11.7%	
	Commercial/Industrial	304.7	2.5%	
	Institutional	217.7	1.8%	
Agriculture	Pasture/Hay/Livestock	373.8	3.1%	3.2%
	Row Crop	11.5	0.1%	
Forest	Deciduous Forest	3,581.3	29.5%	36.5%
	Evergreen Forest	367.5	3.0%	
	Mixed Forest	474.7	3.9%	
Other	Quarries/Strip Mines/Gravel Pits	0.6	0.0%	1.5%
	Transitional	13.3	0.1%	
	Urban/Recreational Grasses	2.9	0.0%	
	Golf Course	159.4	1.3%	
		12,120	100.%	100%

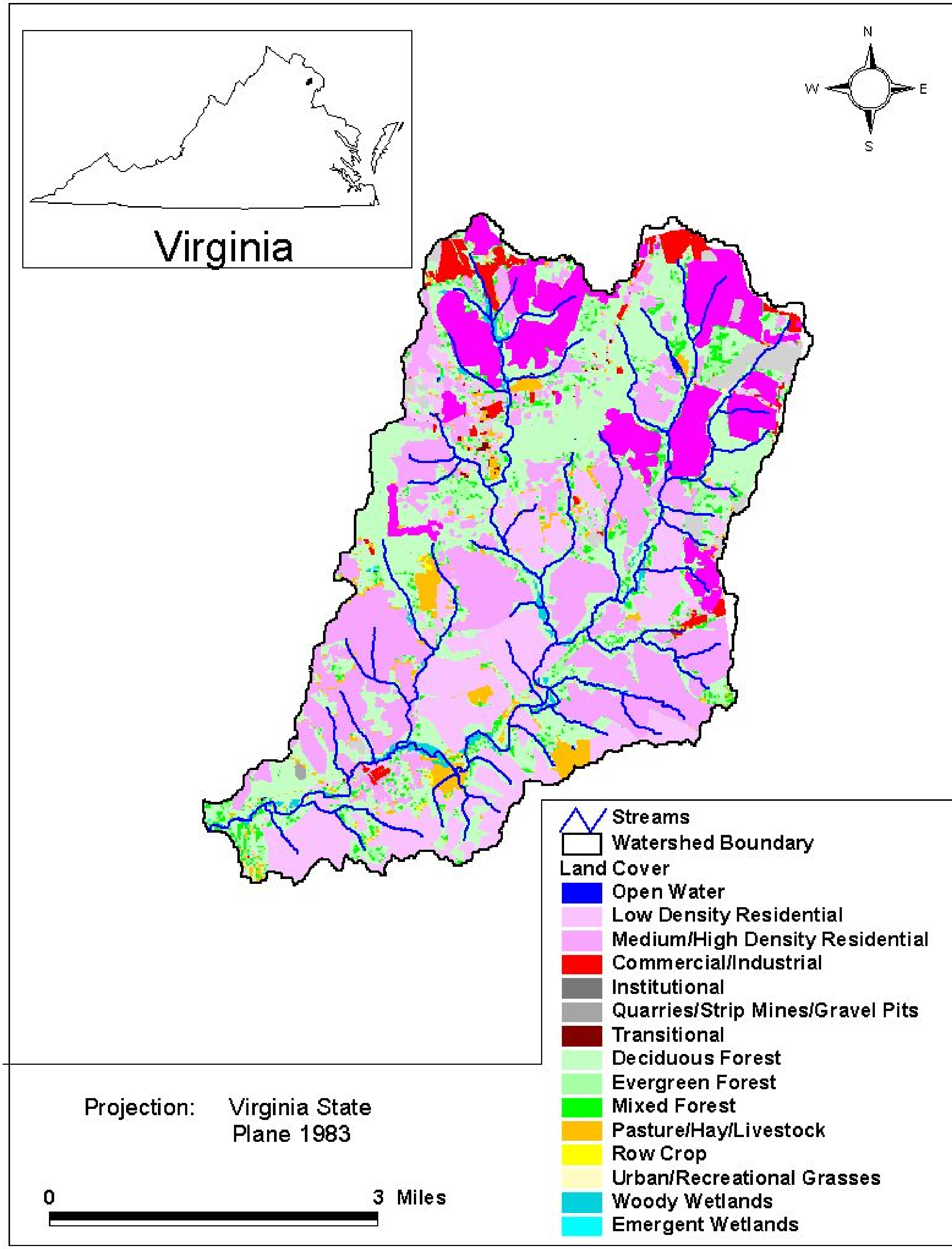

Figure 2-2: Land Use in the Popes Head Creek Watershed

2.1.6 Ecoregion Classification

The Popes Head Creek watershed straddles the Northern Piedmont ecoregion and the Piedmont ecoregion, USEPA Level III classification numbers 64 and 45, respectively (Woods et al., 1999). The location of the Popes Head Creek watershed within these ecoregions is presented in **Figure 2-3**. The Northern Piedmont ecoregion is a region of low rounded hills, irregular plains, and open valleys that serves as a transitional area between the low mountains to the north and west and the flat coastal plains to the east. Natural vegetation in the Northern Piedmont ecoregion is predominantly Appalachian oak forest, in contrast to the mostly oak-hickory-pine forests of the Piedmont ecoregion to the southwest.

The Piedmont ecoregion extends from Wayne County, Pennsylvania southwest through Virginia, and comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. Once largely cultivated, much of this region has reverted to pine and hardwood woodlands. The Piedmont ecoregion is characterized by shallow valleys, irregular plains, and low rounded hills and ridges. The underlying geology of this region consists of deeply weathered, deformed metamorphic rocks with intrusions by igneous material.

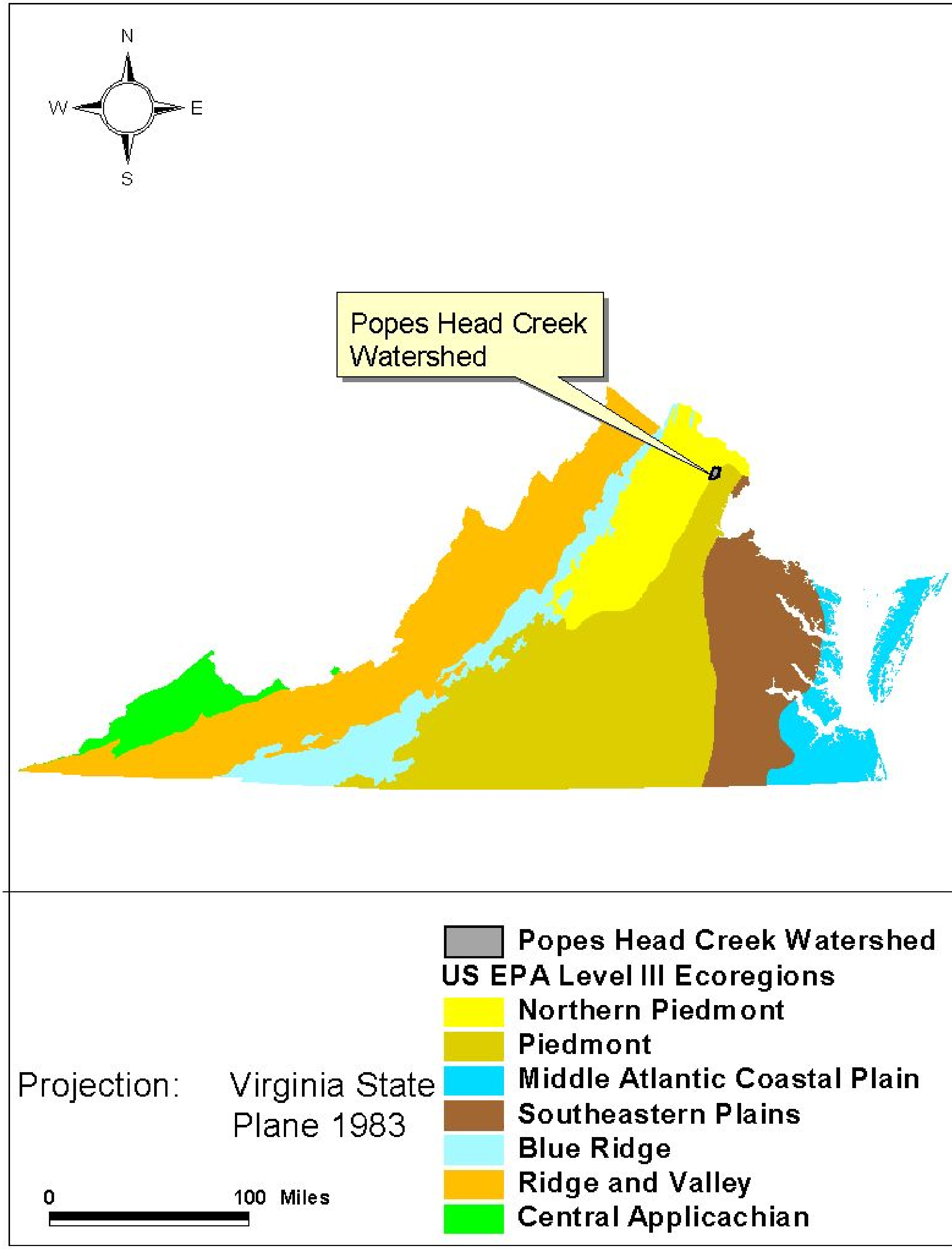

Figure 2-3: Virginia Level III Ecoregions

2.2 Permitted Discharge Facilities

There are no facilities holding active individual permits in the Popes Head Creek watershed. There are estimated to be 7 active general permits in the Popes Head Creek watershed; 3 permits issued to domestic sewage facilities, and 4 stormwater permits issued to construction sites based on estimates from DCR. There was no information on the exact locations on these 4 stormwater construction permits. The permit number, type, permitted flow, and receiving waterbody of the facilities holding domestic sewage general permits are presented in **Table 2-4**.

Table 2-4: Domestic Sewage General Permits Issued in the Popes Head Creek Watershed

Permit	Facility	Design Flow (gal/day)	Receiving Stream
VAG406296	Residence	600	Piney Branch UT
VAG406202	Residence	450	Piney Branch, UT
VAG406252	Residence	1000	Pope's Head Creek, UT

In addition to the general permits presented above, four (4) Municipal Separate Storm Sewer (MS4) permits have been issued to Cities, Towns, Counties, and other facilities within the Popes Head Creek Benthic Watershed. **Table 2-5** lists all the MS4 permit holders with the area covered by each MS4 locality. The MS4 County and City areas were calculated using the US Census Urban Areas and subtracting the acreages for the VDOT road areas. VDOT road areas were estimated using the roads length within the urban areas and assuming a 25 foot-road-width. Combined, these MS4 permits cover approximately 99.8% of the Popes Head Creek benthic impairment watershed. **Figure 2-4** presents the major MS4 localities located within the Popes Head Creek Benthic Watershed.

Table 2-5: MS4 Areas within the Popes Head Creek Watershed

<table>
<tr><th>MS4 Permit Number</th><th>MS4 Permit Holder</th><th>MS4 Locality</th><th>Acres</th></tr>
<tr><td>VA0088587</td><td>Fairfax County</td><td rowspan="3">Fairfax County</td><td rowspan="3">11,926.0</td></tr>
<tr><td>VAR040104</td><td>Fairfax County Public Schools</td></tr>
<tr><td>VAR040062</td><td>VDOT Urban Area</td></tr>
<tr><td>VAR040064</td><td>City of Fairfax</td><td rowspan="2">City of Fairfax</td><td rowspan="2">171.5</td></tr>
<tr><td>VAR040062</td><td>VDOT Urban Area</td></tr>
<tr><td colspan="3">Total</td><td>12,097.5</td></tr>
</table>

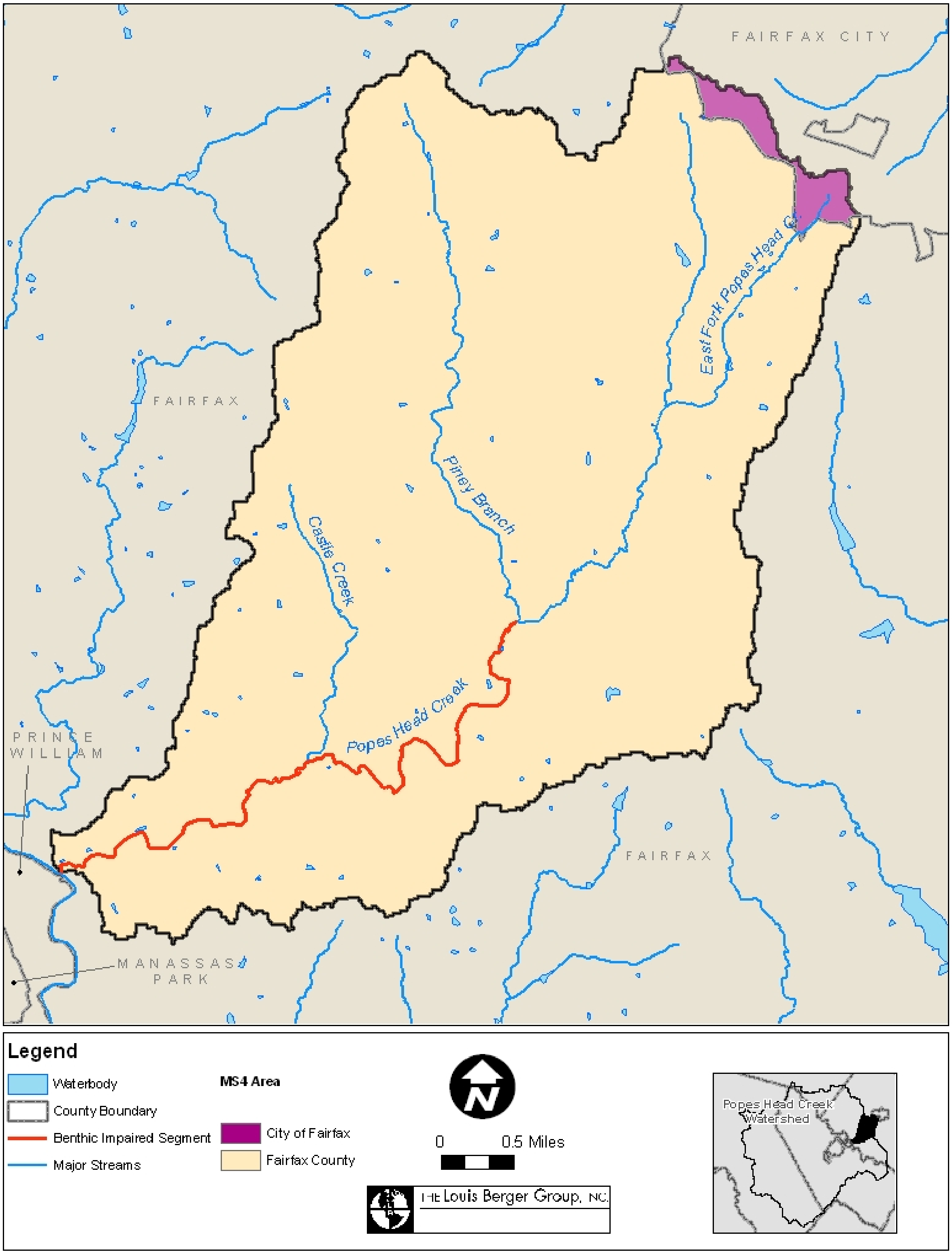

Figure 2-4: Major MS4 Areas within the Popes Head Creek Watershed

2.3 DEQ Monitoring Stations

DEQ has several monitoring stations on Popes Head Creek which are used for biological and ambient water quality monitoring. A summary list of the DEQ monitoring stations located on Popes Head Creek is presented in **Table 2-6**, and the locations of these stations are presented in **Figure 2-5**. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek.

Monitoring station 1APOE002.00 contained the longest and most recent ambient water quality data record, and thus was the primary source of water quality data used in the stressor identification and TMDL development. Biological monitoring data were also collected at station 1APOE002.00; Popes Head Creek was classified as impaired based on the results of bioassessment surveys conducted at this station. A detailed discussion of the available environmental monitoring data is presented in Section 3.0.

Table 2-6: Summary of Monitoring Stations on Popes Head Creek

Station ID	Station Type	Period Of Record
1APOE001.55	Ambient Water Quality	1977-1988
1APOE002.00	Ambient and Biological	1990-2005
1APOE005.40	Ambient Water Quality	1977-1988
1APOE007.20	Ambient Water Quality	1988
1APOE008.36	Ambient Water Quality	1977-1988

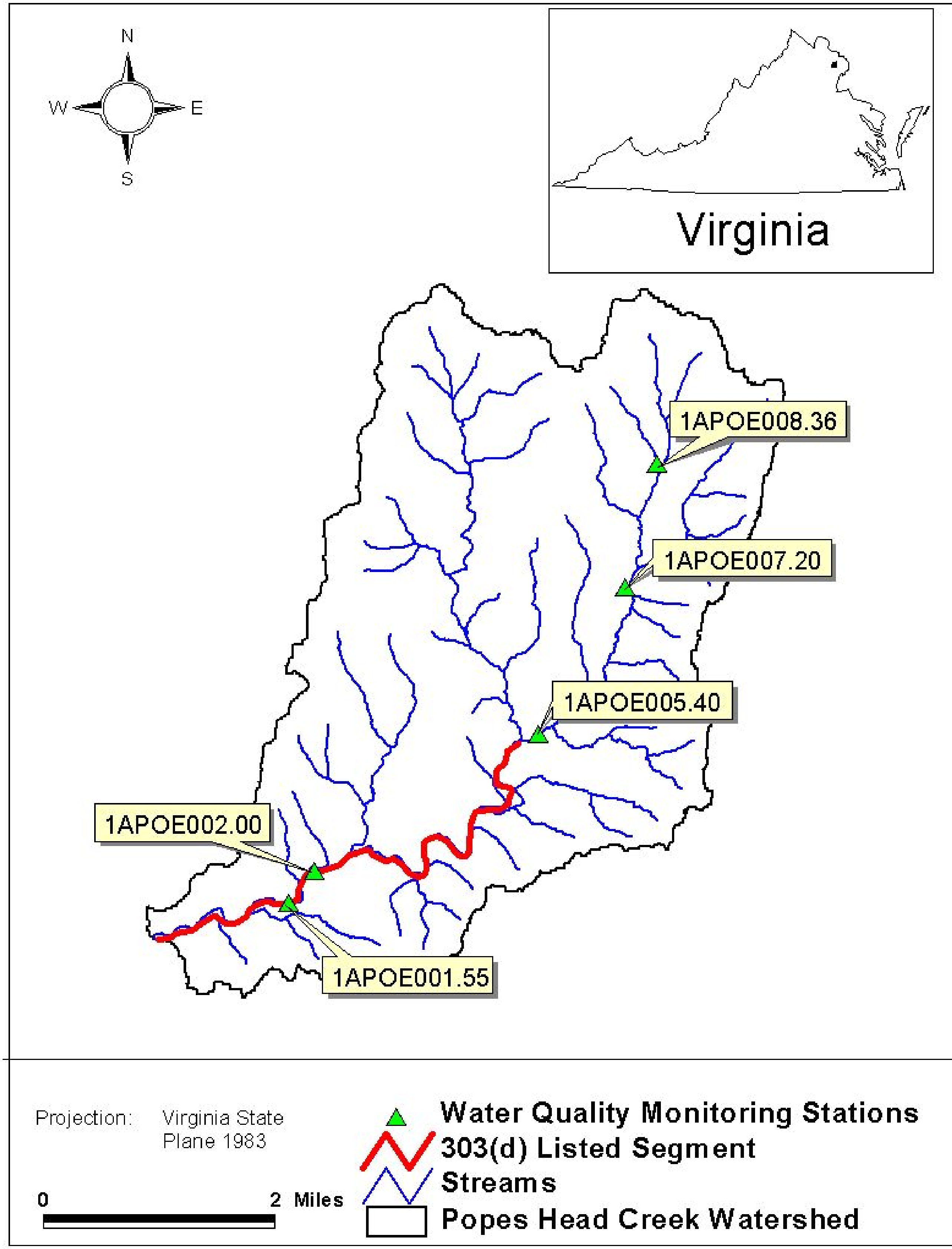

Figure 2-5: DEQ Monitoring Stations in the Popes Head Creek Watershed

2.4 Overview of the Popes Head Creek Watershed

Developed lands (56.9%), forested lands (36.9%), and agricultural lands (3.5%) represent the dominant land uses in the Popes Head Creek watershed. There are 7 facilities holding active general permits in the watershed, and no individual permitted facilities. Biological monitoring has been conducted by DEQ at station 1APOE002.00 on the biologically impaired segment of Popes Head Creek, and DEQ has collected ambient water quality data at five additional stations in the watershed. The land use and the locations of the monitoring stations in the watershed are shown in the summary map presented in **Figure 2-6**.

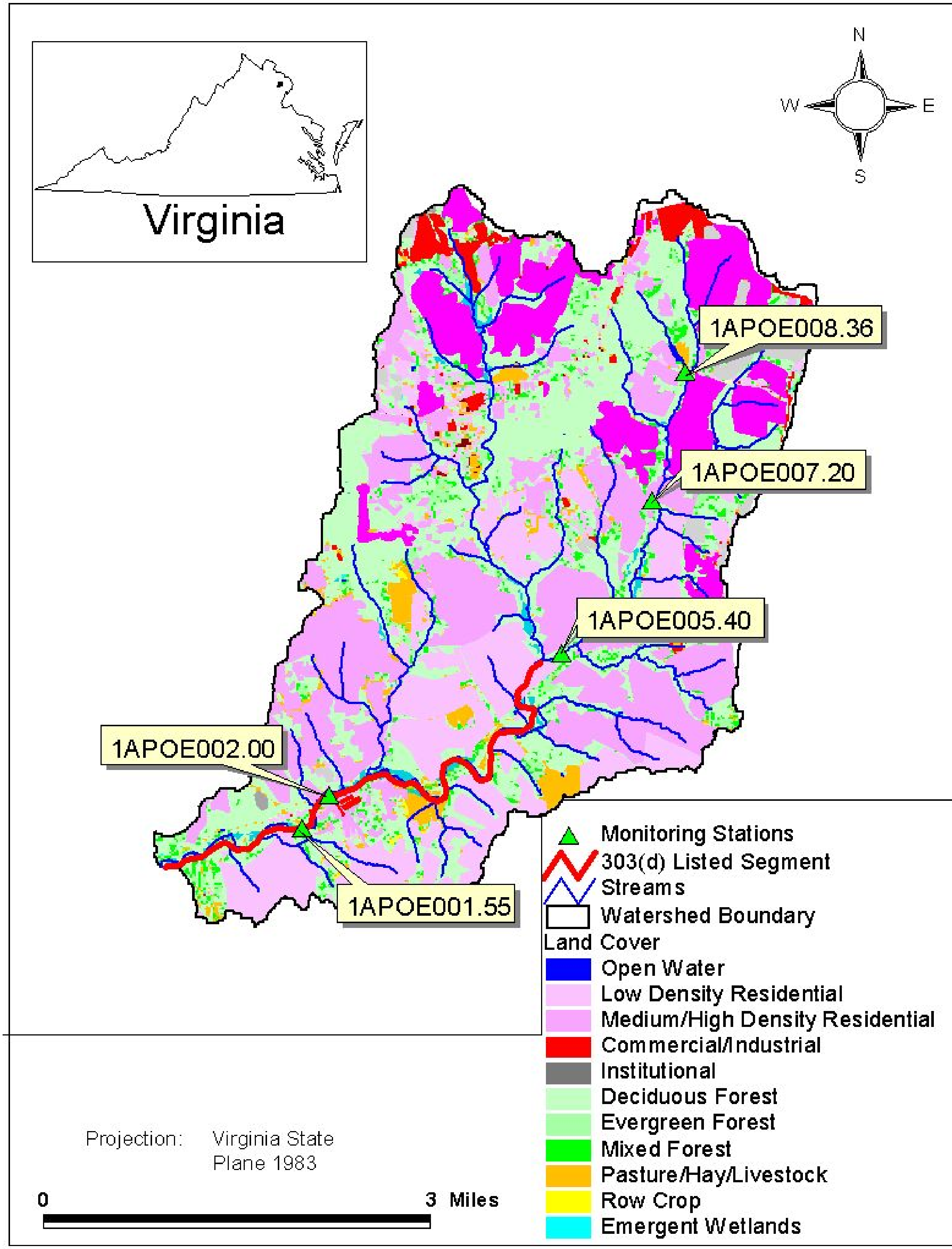

Figure 2-6: Overview of Popes Head Creek Watershed

3.0 Environmental Monitoring

Environmental monitoring efforts in the Popes Head Creek watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, and toxicity testing. Monitoring efforts have been conducted by the Virginia Department of Environmental Quality (VADEQ), Fairfax County Stormwater Planning Division, and Audubon Naturalist Society (ANS), a citizen monitoring group. **Figure 3-1** plots the location of all monitoring locations in the Popes Head Creek watershed used for this analysis.

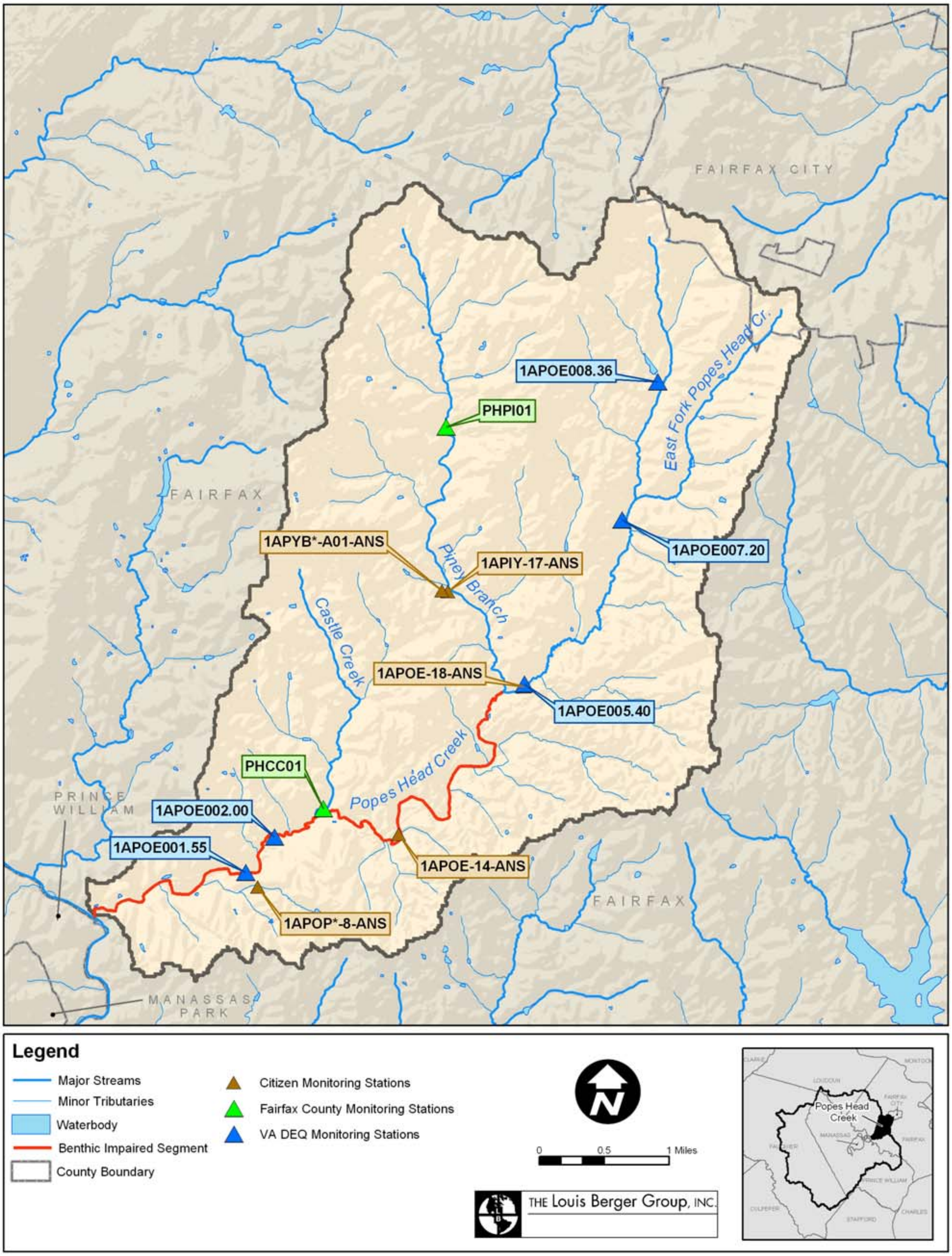

Figure 3-1: Monitoring Locations in the Popes Head Creek Watershed

3.1 Virginia Department of Environmental Quality Data

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is impacting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor impacting the biologically impaired segment of Popes Head Creek. Analyzed data included available biological and water quality monitoring data, and results from recent DEQ instream toxicity studies conducted on Popes Head Creek. The collection period, content, and monitored sites for these data are summarized in **Table 3-1**. The locations of the monitoring stations are presented in **Figure 3-1**. As stated previously in Section 2.0, no individual permitted facilities discharge into the Popes Head Creek watershed.

Table 3-1: Inventory of Environmental Monitoring Data for Popes Head Creek

Data Type	Collection Period	Monitoring Stations					Fairfax County Monitoring Stations
		1APOE001.55	1APOE002.00	1APOE005.40	1APOE007.20	1APOE008.36	
DEQ Biological Monitoring	1994-2004		X				
DEQ Ambient Water Quality Monitoring	1977-2004	X	X	X	X	X	
DEQ Field Water Quality Monitoring	1994-2004		X				
DEQ Toxicity Study	April 2004, May 2005		X				
Fairfax County Biological Monitoring	1999-2004						X

3.1.1 Biological Monitoring Data

The impaired segment of Popes Head Creek was included on Virginia’s 1998 Section 303(d) List of Impaired Waters and was subsequently included on Virginia’s 2002 Section 303(d) List of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report based on biomonitoring results obtained between 1997 and 2004.

RBPII Scores

A modified version of the EPA Rapid Bioassessment Protocols II (RBPII) was used to assess the biological condition of the river’s benthic invertebrate communities. Candidate RBPII metrics, as specified in EPA’s Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers, Second Edition (Barbour et al., 1999), are presented in **Table 3-2**. RBPII assessment ratings for the biomonitoring surveys conducted on Popes Head Creek are presented in **Table 3-3**.

Virginia DEQ bioassessments follow a paired reference approach using upstream stations located in the same watershed. The DEQ protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures (**Table 3-2**).

DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on Popes Head Creek contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of each survey

Table 3-2: Candidate RBPII Metrics Specified in Barbour et al. (2002)

Category	Metric	Definition	Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

Table 3-3: RBPII Assessment Ratings for Popes Head Creek Biomonitoring Surveys

Collection Period	Assessment Rating
	Station 1APOE002.00
Spring 1997	Moderate Impairment
Fall 1997	Moderate Impairment
Spring 1998	Moderate Impairment
Fall 1998	Moderate Impairment
Spring 1999	Slight Impairment
Fall 1999	Moderate Impairment
Spring 2000	Moderate Impairment
Spring 2004	Slight Impairment
Fall 2004	Slight Impairment
Spring 2005	Slight Impairment

Biomonitoring surveys were conducted biannually at 1APOE002.00 from 1997 to 2000, and then again in 2004 to the spring of 2005. During this period, the benthic community was consistently listed as impaired; 'moderately' for 6 out of 10 sampling events and 'slightly' for the remaining 4. Three RBPII metrics contributing to the overall impairment ratings consistently showed scores that were lower than those observed at the reference site. The first two, EPT to Chrionomidae abundance ratios (which compares the total number of mayflies, stoneflies, and most caddisflies which are mostly sensitive to pollution, to the number of midges, a predominantly tolerant family) and the EPT index (the total number of distinct taxa within the EPT groups), estimate the relative abundance of sensitive species present in the community and are therefore general indicators of water quality conditions. The last metric, the ratio of the shredder functional feeding group to the total number of individuals, is an indicator of riparian zone impacts and potential toxic effects.

Despite consistently impaired conditions, overall assessment ratings appeared to show a mild improvement during recent sampling events. Specifically, moderately impaired benthic communities were consistently observed at the beginning of the sampling record while more recent samples have indicated only slight impairment. Before 2000, RPBII scores were often more than 20 points lower than those recorded in 2004 and 2005. The

EPT index was one metric that showed improvement during this period. Before 2001 the number of taxa within the EPT groups generally ranged between 2 and 4, but in 2004 and 2005 increased to between 5 and 7.

Although as a whole, most metrics improved in recent sampling events, some declined. For example, the MFBI (Modified Family Biotic Index) tended to be worse in recent samples. Values were frequently observed above 4.5, which may indicate organic pollution is affecting the benthic community. Additionally, the percent of dominant species in the sample was also notably higher than the percent observed at the reference site in recent sampling events. Though some of these changes may likely be related to rainfall variations over the past decade (drought conditions were observed in the pre-2000 sampling events) they are presented here for future reference and review until additional sampling data is available.

3.1.2 Virginia Stream Condition Index (SCI) Scores

Using the data collected during biomonitoring surveys, biological assessment scores were calculated using the Virginia Stream Condition Index (SCI) currently being developed by DEQ. The SCI is a regionally-calibrated index comprised of eight metrics that are listed in **Table 3-4**. The metrics used in calculation of an SCI score are similar to the metrics used in RBPII assessments. However, unlike RBPII, the reference condition of the SCI is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 61.3 has been proposed for assessing results obtained with the SCI. Streams that score greater than 61.3 are considered to be non-impaired, whereas streams that score less than 61.3 are considered impaired.

Calculated SCI scores for the biomonitoring station 1APOE002.00, located on Popes Head Creek, are presented in **Table 3-5**. SCI scores calculated for station 1APOE002.00 were, on average, below the proposed impairment cutoff score of 61.3; therefore, the station is considered to be impaired. Station 1ACAX004.57, located on Catoctin Creek, served as the reference station for the Popes Head Creek biological assessment from 1997 to 2000. However, this monitoring station was discontinued as a reference site after 2000 due to a decline in the observed benthic community at this location. Station 1AGOO022.44, located on Goose Creek, served as the reference station for the biological assessments conducted on Popes Head Creek in 2004. Both of the reference stations had average SCI scores above the proposed impairment cutoff score.

Table 3-4: Metrics Used to Calculate the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Table 3-5: Virginia SCI Scores for Popes Head Creek

Collection Period	SCI Score		
	1APOE002.00	1ACAX004.57[1]	1AGOO022.44[2]
Spring 1997	48.3	69.7	-
Fall 1997	56.2	74.8	-
Spring 1998	49.6	73.6	-
Fall 1998	56.4	68.7	-
Spring 1999	59.0	72.5	-
Fall 1999	48.2	70.5	-
Spring 2000	33.7	70.5	-
Fall 2000	-	68.0	-
Spring 2004	51.4	-	67.6
Fall 2004	48.2	-	62.6
Spring 2005	55.0		-
Average	**50.6**	**71.1**	**65.1**

1: Monitoring station 1ACAX004.57 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.3 Habitat Assessment Scores

A suite of habitat variables were visually inspected at station 1APOE002.00 as part of the DEQ biological assessments conducted on Popes Head Creek. Habitat parameters that were examined include channel alteration, sediment deposition, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Habitat assessment scores for the Popes Head Creek biomonitoring station, as well as the reference stations, are presented in **Table 3-6**.

Overall habitat assessment scores were generally lower at impaired station 1APOE002.00 than at the reference stations. Specifically, assessments scores for habitat metrics such as substrate embeddedness and riparian zone vegetation were, on average, lower at the impaired station than at the reference stations. Average assessment scores for other habitat metrics were generally similar between the reference and impaired stations.

Table 3-6: Habitat Scores for Reference and Impaired Stations

Station ID	Date	Total Habitat Score	Channel Alteration	Bank Stability	Bank Vegetative Protection	Substrate Embeddedness	Channel Flow	Riffles	Riparian Vegetative Zone	Sediment Deposition	Velocity Regime
1APOE002.00	Spring 1997	158	17	18	17	12	18	18	12	15	17
	Fall 1997	166	17	18	17	14	19	18	12	16	18
	Spring 1998	161	17	16	17	14	18	15	14	16	17
	Fall 1998	157	18	17	17	12	18	14	15	15	15
	Spring 1999	165	18	18	17	14	18	16	15	16	16
	Fall 1999	168	18	17	18	14	18	18	15	16	18
	Spring 2000	164	19	18	17	14	19	18	14	15	14
	Spring 2004	149	19	16	10	14	18	17	11	14	17
	Fall 2004	155	20	17	14	14	17	17	11	14	15
	Average	**160.3**	**18.1**	**17.2**	**16.0**	**13.6**	**18.1**	**16.8**	**13.2**	**15.2**	**16.3**
1ACAX004.57	Spring 1997	180	19	17	17	18	19	18	17	18	19
	Spring 1998	177	19	18	18	17	18	17	17	17	17
	Fall$_1$ 1998	170	17	17	17	16	18	17	17	16	18
	Fall$_2$ 1998	176	18	17	18	19	18	17	17	18	16
	Spring 1999	179	18	18	18	18	19	18	17	17	18
	Fall 1999	163	18	17	17	14	19	17	16	10	18
	Spring 2000	164	18	15	17	15	19	16	15	14	18
	Fall 2000	165	18	14	16	17	18	17	16	16	16
	Average	**170.5**	**18.1**	**16.7**	**17.1**	**16.4**	**18.5**	**17.1**	**16.1**	**15.7**	**17.4**
1AGOO022.44	Spring 2004	174	19	17	19	16	18	16	19	16	17
	Fall 2004	176	20	18	18	16	18	16	19	15	19
	Average	**170.8**	**18.2**	**16.6**	**17.5**	**16.4**	**18.4**	**16.8**	**16.9**	**15.3**	**17.5**

1: Monitoring station 1ACAX004.57 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.4 Water Quality Monitoring

There are five DEQ ambient water quality monitoring stations located in the Popes Head Creek watershed. Information on each ambient monitoring station is summarized in **Table 3-7**. Monitoring station 1APOE002.00 represents the largest sources of water quality data available in the watershed, and the only station at which recent monitoring data are available.

Table 3-7: Ambient Water Quality Monitoring Stations on Popes Head Creek

Station Id	Station Location	Period of Record	River Mile	No. Sampling events
1APOE001.55	Intersection with Route 659	1977-1988	1.55	2
1APOE002.00	Intersection with Route 645	1990-2004	2.00	78
1APOE005.40	Intersection with Route 660	1977-1988	5.40	2
1APOE007.20	Intersection with Route 654	1988	7.20	1
1APOE008.36	Intersection with Route 620	1977-1988	8.36	2

3.1.5 Instream Water Quality Data

Popes Head Creek is classified as a Class III waterbody (Nontidal Waters), as defined in Virginia Water Quality Standards (9 VAC 25-260-50). Thus, water quality parameters in the impaired segment must meet the Class III standards (**Table 3-8**).

Table 3-8: Virginia Water Quality Standards for Popes Head Creek

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Average		
III	Nontidal Waters	4.0	5.0	6.0-9.0	32

Instream water quality data collected on Popes Head Creek at station 1APOE002.00 from 1990 to 2004 are presented in **Figures 3-2** to **3-12**. The following is a bulleted summary of the monitoring data:

- Field dissolved oxygen, pH, and temperature values have been in compliance with numeric criteria for Class III waters (**Figures 3-2, 3-3, 3-4, 3-6**).
- Biochemical oxygen demand concentrations at the station were low (**Figure 3-7**).
- Suspended solids concentrations and conductivity levels were variable; observed values were low for most sampling events, but elevated suspended solids concentrations were observed in some instances (**Figure 3-5** and **Figure 3-8**).

- Nitrate, ammonia, and total phosphorus concentrations were generally low across all sampling events (**Figures 3-9** to **3-11**).

- Several violations of the Virginia fecal coliform instantaneous standard occurred at monitoring station 1APOE002.00 (**Figure 3-12**); a bacteria TMDL is currently being developed for Popes Head Creek and will be presented in a separate report.

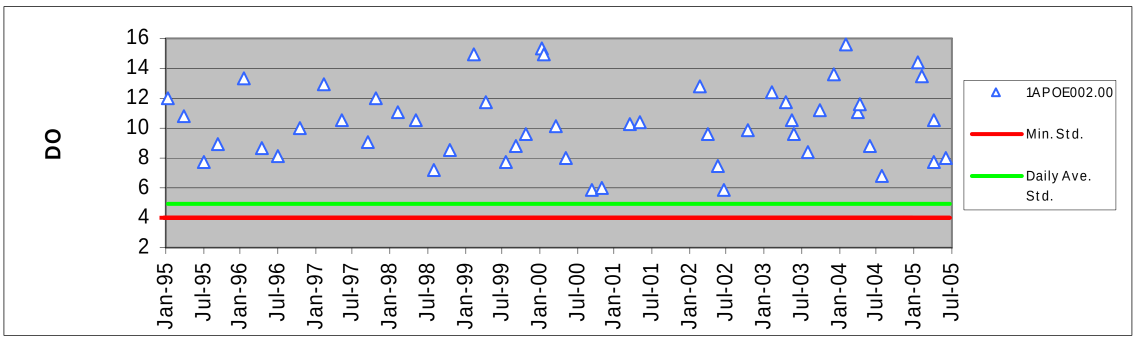

Figure 3-2: **Popes Head Creek Field Dissolved Oxygen Concentrations**

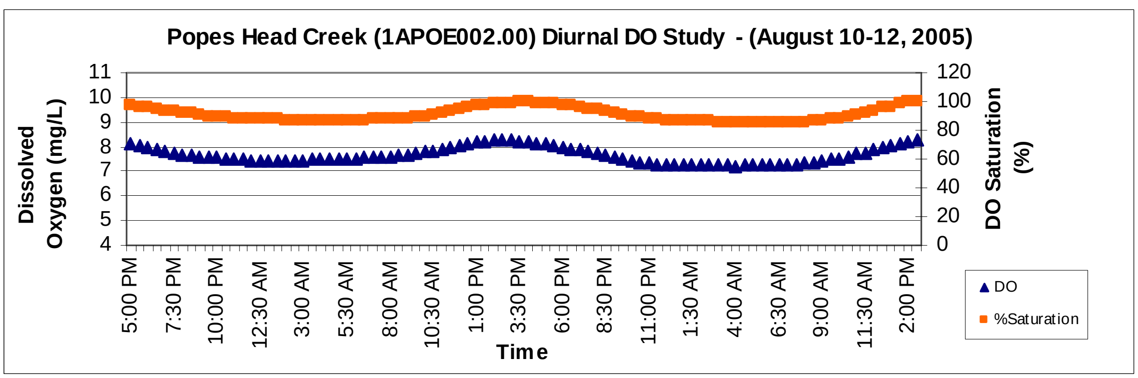

Figure 3-3: Popes Head Creek Diurnal DO Concentrations

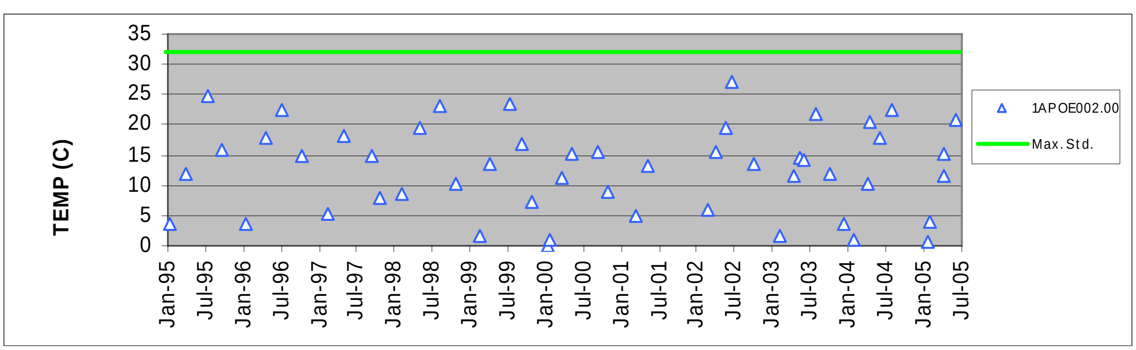

Figure 3-4: Popes Head Creek Field Temperature Data

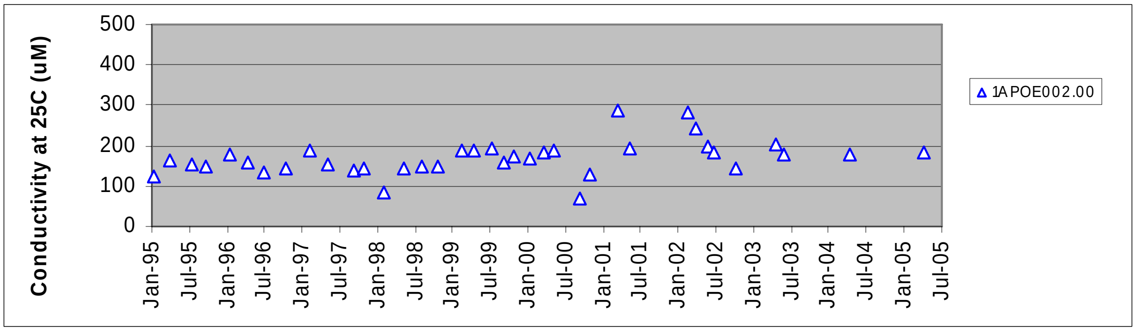

Figure 3-5: Popes Head Creek Conductivity Data

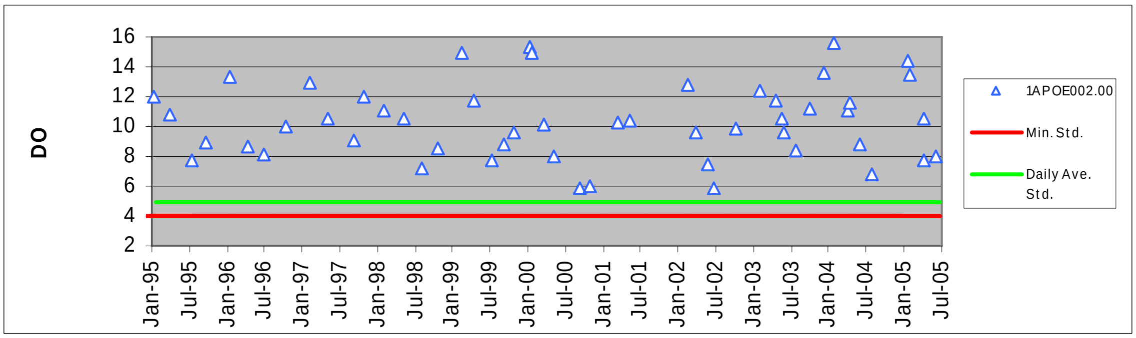

Figure 3-6: Popes Head Creek Field pH Data

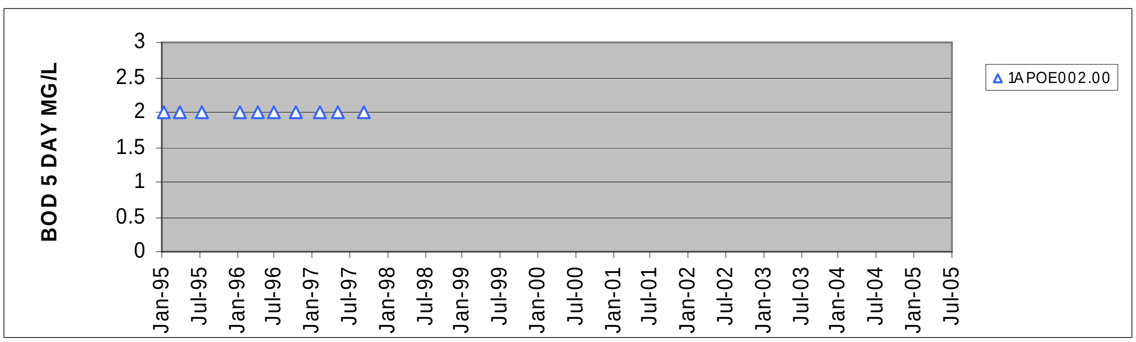

Figure 3-7: Popes Head Creek Biochemical Oxygen Demand Concentrations

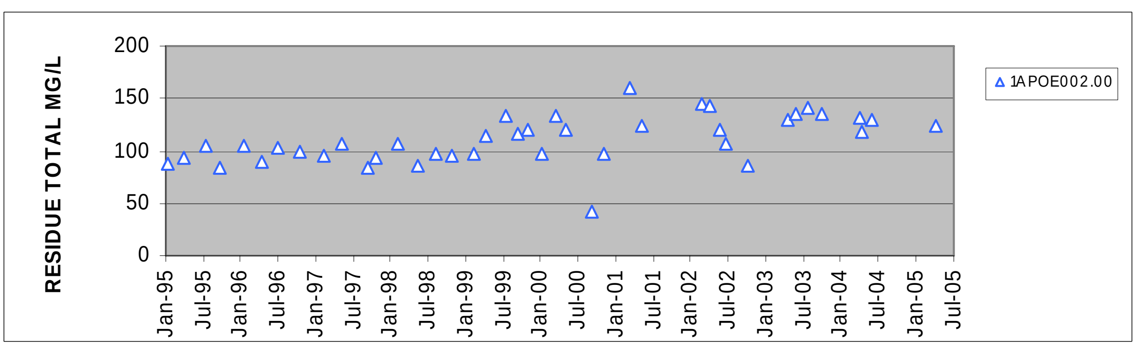

Figure 3-8: Popes Head Creek Suspended Solids Concentrations

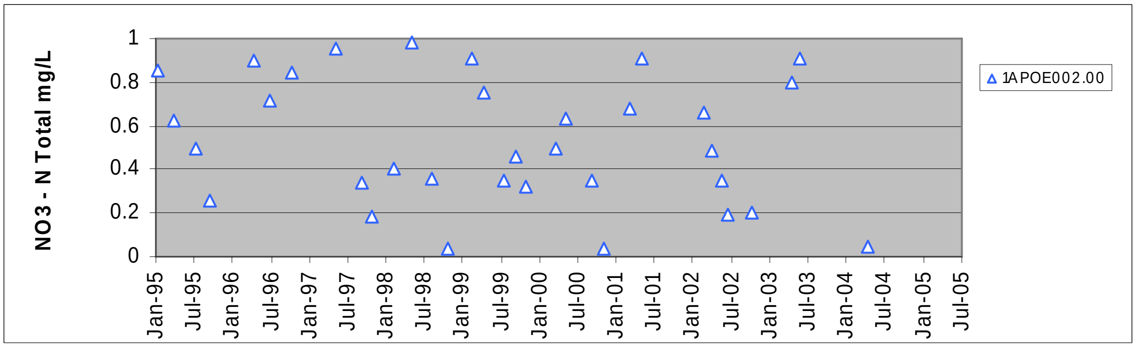

Figure 3-9: Popes Head Creek Nitrate Concentrations

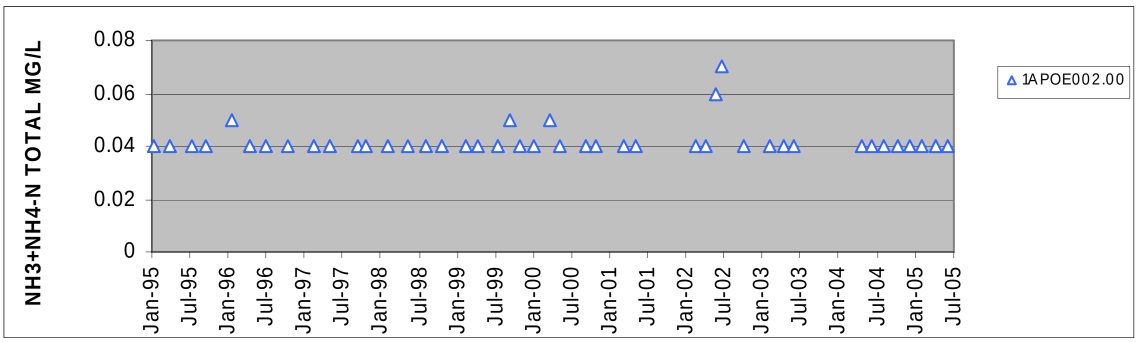

Figure 3-10: Popes Head Creek Ammonia Concentrations

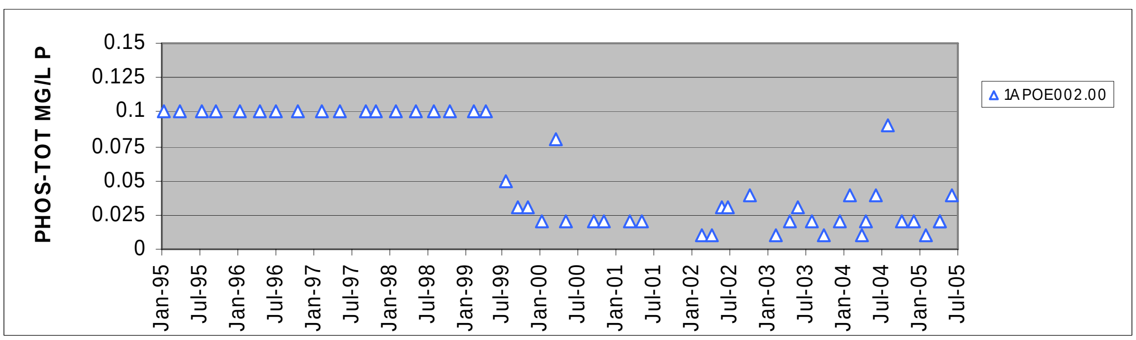

Figure 3-11: Popes Head Creek Total Phosphorus Concentrations

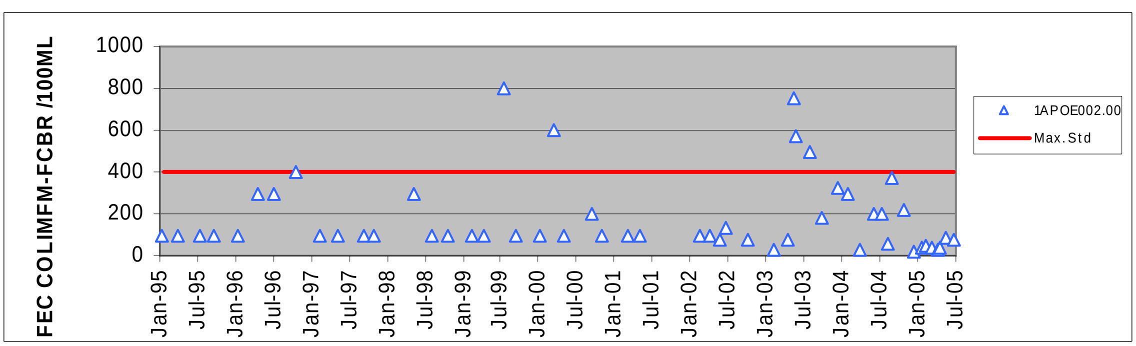

Figure 3-12: Popes Head Creek Fecal Coliform Concentrations

3.1.6 Metals Data

Both dissolved (water column) and sediment metals parameters were examined in Popes Head Creek, including arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. All available dissolved metals data collected on Popes Head Creek were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards. No monitored metals parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's chronic or acute aquatic life use standards.

Additionally, although there are currently no water quality standards established for sediment metals, the 2006 DEQ assessment guidance memorandum (DEQ, 2006b) establishes consensus based sediment screening values for use in determining aquatic life use support. The sediment metals data collected on Popes Head Creek were analyzed to determine whether they complied with the consensus based screening values. None of the available sediment metals data exceeded the sediment screening values specified in the DEQ 2004 assessment guidance memorandum.

3.1.7 Organics Data

Organics data collected on Popes Head Creek include dissolved (water column) and sediment samples analyzed for aldrin, dieldrin, endosulfan, endrin, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and PCBs. All available organics data collected on Popes Head Creek were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards and sediment screening values. Organics concentrations were below detection limits for almost all of the samples analyzed. No monitored organics parameters exceeded acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Additionally, none of the available sediment organics data exceeded the sediment screening values specified in the DEQ 2006 assessment guidance memorandum.

3.1.8 Toxicity Testing

Toxicity testing was performed on water samples collected on Popes Head Creek by DEQ on April 12th, 14th, and 16th, 2004 and on May 2nd and 4th 2005 at station 1APOE002.00. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and *Ceriodaphnia dubia* as test organisms.

Results on samples collected in 2004 indicated *Ceriodaphnia* mortality and reproduction in the Popes Head Creek water samples were statistically different than mortality and reproduction in the control samples, thus indicating that there were toxic water column effects to *Ceriodaphnia* in the Popes Head Creek samples. *Ceriodaphnia* survival in the Popes Head Creek samples was zero percent, as compared to 100 percent survival in the control samples. Fathead minnow growth in the Popes Head Creek water samples in 2004 was not statistically different from growth in the control samples. However, fathead minnow survival in samples collected at station 1APOE002.00 did significantly vary from minnow survival in the control samples. Minnow survival in samples collected at station 1APOE002.00 was 63 percent, which was statistically different from the laboratory control and provided further indication of toxicity in the Popes Head Creek water samples.

Additional samples were collected for toxicity testing by DEQ at station 1APOE002.00 on May 2nd and 4th, 2005. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on these samples using the same protocol as described above. In contrast to results from samples taken in 2004, results from samples taken in May 2005 did not show any toxic effects on *Ceriodaphnia* mortality and reproduction. However, fathead minnow survival in samples collected at station 1APOE002.00 was approximately 60% percent, which was statistically different from the laboratory control. In addition, these samples also had a significant effect on the biomass of the fathead minnows which is further indication of toxicity in the Popes Head Creek water samples.

The EPA Region 3 laboratory in Wheeling, WV indicated that in their professional judgment, the difference in mortality rates between the samples taken at station

1APOE002.00 and the control was "*probably biologically significant*." In both instances, the EPA Region 3 laboratory emphasized that these results were qualitative in nature, and needed to be compared to other available water quality data.

3.2 Supplemental Monitoring Data

3.2.1 Fairfax County Biomonitoring Data

The Fairfax County Stormwater Planning Division Stream Protection Strategy (SPS) program conducted biomonitoring surveys in the Popes Head Creek watershed between 1999 and 2004. Fairfax County biological monitoring followed protocols similar to those used by the DEQ and uses the Virginia SCI method to calculate biological assessment scores for the sampled reaches (**Table 3-4)**. However, Fairfax County applies its own assessment rating terminology. The 'Impaired 1' assessment rating corresponds to a slight impairment, while the 'Impaired 2' assessment rating reflects a more severe impairment. The 'Reference' assessment rating indicates that the benthic invertebrate community collected at that site corresponds to a score above an SCI rating of 60. As indicated in **Table 3-9**, the Fairfax County SCI scores for Popes Head Creek were generally given the 'Impaired 1' or 'Impaired 2' assessment rating, and exceeded the cutoff of 60 on only one occasion. The results of the Fairfax County biological surveys were generally consistent with the DEQ biomonitoring results.

Table 3-9: Fairfax County SCI Scores for Popes Head Creek

Year	SCI Scores and Assessment Rating by Sample Station						
	PHCC01	PHPH01	PHPH02	PHPH03	PHPI01	PHPI02	PH0401
1999	**44.1** *Impaired 1*	**25.8** *Impaired 2*	**41.4** *Impaired 1*	**30.2** *Impaired 2*	**24.7** *Impaired 2*	**22.7** *Impaired 2*	NA
2001	**75.1** *Reference*	**41** *Impaired 1*	NA	NA	NA	NA	NA
2004	NA	NA	NA	NA	NA	NA	**22.6** *Impaired 2*

3.2.2 Citizen Monitoring Data

Biological and habitat monitoring data was collected within the Bull Run Watershed by the Audubon Naturalist Society (ANS), a citizen monitoring group. ANS uses a modified version of the U. S. Environmental Protection Agency (EPA) Rapid Bioassessment II Protocol for macroinvertebrate collection and habitat assessment. Results obtained using the ANS methods are also used by DEQ for water quality assessments. A summary of ANS data is shown in **Table 3-10**.

Table 3-10: ANS Biological Monitoring Data

Station #	DEQ Site Number	Stream Name	Type	No. of Monitoring Events	Collection Peroid	Quality Rating
8	1APOP*-8-ANS	Unnamed tributary of Popes Head Ck	Biological, Habitat	17	1998-2002	Excellent
14	1APOE-14-ANS	Popes Head Creek	Biological, Habitat	14	1998-2002	Fair
17	1APIY-17-ANS	Piney Branch	Biological, Habitat	13	1999-2002	Fair
18	1APOE-18-ANS	Popes Head Creek	Biological, Habitat	8	2000-2002	Fair
A01	1APYB*-A01-ANS	Unnamed Tributary to Piney Branch	Biological, Habitat	1	1999	Poor
* "Overall Stream Quality Rating" - Cumulative rating based on all monitoring events						

Data summary

Both ANS stations located on Popes Head Creek ranked as fair. Station number 14 is located on the impaired segment and station number 18 is located above Popes Head Creek's confluence with Piney Branch (above the listed segment). Similarly, Piney Branch also ranked as fair, a ranking consistent with the impairment ranking (Impaired 2) reported by the Fairfax County Storm Water Planning Division's site upstream. The remaining two stations were located on small tributaries feeding the mainstem of either Popes Head or Piney Branch. These tributaries ranked excellent and poor (respectively), with the poor rating on the Piney Branch tributary presumably due to a lack of favorable habitat characteristics at this site.

3.3 Permitted Facilities

As indicated in Section 2.0, there are no individually permitted facilities discharging into the Popes Head Creek watershed. There are seven general permits present in the watershed including three (3) domestic sewage general permits (**Table 2-4**). In addition, there are 4 stormwater permits issued to construction sites in the Popes Head Creek watershed. There was no information available on the exact locations of these 4 stormwater construction permits.

4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of the Popes Head Creek watershed was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA 2000).

The identification of the most probable cause of biological impairment in the Popes Head Creek watershed was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as pH, temperature, dissolved oxygen, sediment, ammonia, flow modification, and toxic compounds. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with the conclusive data linking them to the poorer benthic community. **Table 4.1** summarizes the results of the analysis.

Table 4-1: Summary of Stressor Identification in the Popes Head Creek Watershed

Parameter	Location in Document
Non-Stressors	
Dissolved Oxygen	Section 4.1.1
Temperature and pH	Section 4.1.2
Metals	Section 4.1.3
Organics	Section 4.1.4
Possible Stressors	
Toxicity	Section 4.2.1
Most Probable Stressors	
Sedimentation and Urban Runoff	Section 4.3.1

4.1 Non-Stressors

4.1.1. Dissolved Oxygen

Adequate dissolved oxygen (DO) levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the river's benthic community. Field dissolved oxygen data presented in **Figure 3-2** indicates adequate DO levels in the Popes Head Creek watershed. Similarly, the DO diurnal study conducted between August 10 and August 12, 2005 shows that DO levels remained above the minimum DO standards (**Figure 3-3**).

Consequently, Dissolved oxygen does not appear to be adversely impacting benthic communities in the Popes Head Creek watershed; therefore, it is classified as a non-stressor.

4.1.2. Temperature and pH

Benthic invertebrates require a suitable range of temperature and pH conditions. Although these ranges may vary by invertebrate phylogeny, high instream temperature values and either very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. The Virginia Class III water quality standards identify the acceptable pH and temperature ranges for the Popes Head Creek watershed. Field measurements indicated adequate temperature and pH values on and upstream of the biologically impaired segment (**Figures 3.4** and **3.6**). There have been no observed violations of Class III water quality standards for pH and temperature. Temperature and pH do not appear to be adversely impacting benthic communities in the Popes Head Creek watershed and are therefore classified as non-stressors.

4.1.3. Metals

All available dissolved metals data collected by VADEQ (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc) were below the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. Additionally, the sediment metals data collected in the Popes Head Creek watershed complied with the sediment screening values specified in the DEQ 2004 assessment guidance memorandum.

Consequently, instream metals concentrations do not appear to be adversely impacting benthic communities in the Popes Head Creek watershed and are therefore classified as non-stressors.

4.1.4. Organic Chemicals

Dissolved organics parameters (aldrin, dieldrin, endosulfan, endrin, DDD, DDE, DDT, PAHs, and PCBs) did not exceed acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Organics concentrations were below detection limits for almost all of the samples analyzed. Additionally, none of the available sediment organics data exceeded the sediment screening values specified in the DEQ 2004 assessment guidance memorandum.

Consequently, organic compounds do not appear to be affecting the benthic macroinvertebrates in the Popes Head Creek watershed, and are therefore classified as non-stressors.

4.2 Possible Stressors

4.2.1 Toxicity

Levels of ammonia, which is toxic to aquatic organisms in high concentrations, were low across all monitoring stations, and suggests that ammonia is not adversely impacting benthic invertebrates in the biologically impaired segments of the Popes Head Creek watershed.

Instream toxicity testing was performed on water samples collected on Popes Head Creek watershed by DEQ on April 12th, 14th, and 16th, 2004 and on May 2nd and 4th 2005 at station 1APOE002.00. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and *Ceriodaphnia dubia* as test organisms.

As mentioned in Section 3.1.8, the EPA Region 3 laboratory in Wheeling, WV indicated that in their professional judgment, the difference in mortality rates between the samples taken at station 1APOE002.00 and the control was "*probably biologically significant*." In both instances, the EPA Region 3 laboratory emphasized that these results were qualitative in nature, and needed to be compared to other available water quality data.

In summary, these toxicity testing suggest the presence of potential toxicity and are inconclusive to show a direct impact on the benthic community. Therefore, instream toxicity is considered as a possible stressor in the impaired segment of the Popes Head Creek watershed.

4.3 Most Probable Stressors

4.3.1 Sedimentation and Urban Runoff

Excessive sediment loading can negatively impact benthic invertebrate communities by silting over invertebrate habitat, choking invertebrates with suspended sediment particles, and bringing invertebrates into contact with other pollutants that enter surface water via adhesion to sediment particles. In the Popes Head Creek watershed, habitat assessment scores that show poorer substrate embeddedness scores in the impaired segment suggests the presence of increasing sediment loading (**Table 3-6**).

Additionally, the habitat metrics indicate a loss of riparian vegetation. (**Table 3-6**). The loss of riparian vegetation is usually caused by increased urbanization and impervious surfaces in the watershed, which leads to increased overland flow and channel erosion. Urban land uses comprise 59 percent of the watershed, further confirming the presence of higher runoff and stream bank erosion.

Consequently, the habitat assessment scores indicate that high runoff flows and stream bank erosion are the most probable stressors causing the habitat alterations in the Popes Head Creek watershed.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that dissolved oxygen, temperature, and pH, in the biologically impaired segment of Popes Head Creek are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Concentrations of metals and organic chemicals were generally low or below analytical detection limits and are classified as non-stressors. Toxicity testing suggest the presence of potential toxicity, however, the data are inconclusive to show a direct impact on the benthic community. Consequently, instream toxicity is considered as a possible stressor in the impaired segment of the Popes Head Creek watershed.

Based on the evidence and data discussed in the preceding sections, sedimentation, caused by higher runoff flows has been identified as a primary stressor impacting benthic invertebrates in the biologically impaired segments of the Popes Head Creek. Habitat scores indicate decreased habitat quality in the impaired segments because of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, stream bank erosion, and sediment loss from habitat degradation associated with urbanization.

The interrelation between sedimentation, higher runoff flows, and habitat alteration, allows a TMDL for sediments to address habitat degradation as well as increased urban runoff. Improvement of the benthic community in the biologically impaired segment of the Popes Head Creek watershed is dependent upon reducing sediment loadings through stormwater control, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river.

Consequently and to address these issues, a sediment TMDL will be developed for the biologically impaired segment of the Popes Head Creek watershed.

5.0 TMDL Endpoint Identification

TMDL development requires the determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, a reference watershed approach may be used to define the TMDL endpoint.

Popes Head Creek was initially included on the Virginia Section 303(d) list for violations of the General Standard (benthic impairment). As detailed in Section 4.0, sedimentation and urban runoff were identified as the primary stressor causing the benthic impairment in the stream. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric sediment TMDL endpoint for Popes Head Creek.

5.1 Reference Watershed Approach

Under the reference watershed approach, the TMDL endpoint for an impaired watershed is established based on conditions in a similar, but non-impaired reference watershed. In terms of benthic impairment caused by excessive sediment, the TMDL endpoint is the sediment loading rate in the non-impaired reference watershed. Reduction of the sediment loading rate in the impaired watershed to levels comparable to the reference watershed is assumed to be sufficient for recovery of the benthic community in the impaired watershed.

Selection of an appropriate reference watershed is based on similarities in watershed characteristics such as soils, topography, land uses, and ecology. Similar watersheds help to ensure similarities in the benthic communities that potentially may inhabit the streams. Similar watersheds also provide for similar watershed hydrology which influences pollutant loading rates to the stream.

5.2 Selected Reference Watershed

The Goose Creek watershed draining to the DEQ biomonitoring station at Goose Creek river mile 22.44 was selected as the reference watershed for the Popes Head Creek benthic TMDL development. The Goose Creek reference watershed is located about 20 miles northwest of the Popes Head Creek watershed. Both Popes Head Creek and Goose Creek watersheds are located primarily in the Northern Piedmont ecoregion. Goose Creek watershed covers 100,614 acres while Popes Head Creek covers 12,120 acres. **Table 5-1** summarizes important criteria considered in the selection of the reference watershed for the Popes Head Creek. **Figure 5-1** displays a map of the impaired and reference watersheds.

Table 5-1: Criteria Used in Reference Watershed Selection

Criteria	Relevance
Biomonitoring Data	Biomonitoring data is required to confirm the non-impairment status of the reference watershed and allows for comparisons with the impaired watershed.
Ecoregion	The reference and impaired watersheds should belong to the same ecoregion to help ensure similarities in stream ecology.
Topography	Topography influences hydrology and is a major component of stream habitat that affects the structure and composition of benthic communities.
Land Uses	The selected reference watersheds should reflect similar land use distributions. The water quality of streams in a watershed is greatly influenced by land use. Similar land use distributions help to establish achievable TMDL endpoints.
Soils	Soil composition influences watershed runoff, erosion, and stream ecology.
Watershed Size	The reference watershed should be similar in size to the impaired watershed since watershed area influences pollutant loading rates to the stream.
Location	Close proximity to the impaired watershed generally improves overall watershed similarity. In addition, the reference watershed should be near a weather station that may be used to characterize precipitation at both watersheds in order to standardize model simulations.

Figure 5-1: Goose Creek Watershed

5.2.1 Biomonitoring Data

Virginia SCI scores were calculated for biomonitoring station 1APOE002.00 on Popes Head Creek and stations 1AGOO022.44 on Goose Creek. Scores recorded at Goose Creek Station 1AGOO022.44 were compared with scores at biomonitoring stations located on Popes Head Creek (**Table 5-2**). SCI scores provide a measure of stream biological integrity on a regional basis and an impairment cutoff score of 61.3 has been proposed for assessing results obtained with the SCI in the Occoquan watershed. Streams that score greater than 61.3 are considered to be non-impaired, whereas streams that score less than 61.3 are considered impaired. For the last 2 years, Goose Creek monitoring station 1AGOO022.44 has received SCI scores above the regional cutoff. Therefore, Goose Creek above monitoring station 1AGOO022.44 is considered non-impaired and is fully supporting the creek's aquatic life use.

Table 5-2: Virginia SCI Scores for Popes Head Creek and Goose Creek

Collection Period	SCI Score	
	Impaired Station	Reference Station
	1APOE002.00	1AGOO022.44[2]
Spring 1997	48.3	-
Fall 1997	56.2	-
Spring 1998	49.6	-
Fall 1998	56.4	-
Spring 1999	59	-
Fall 1999	48.2	-
Spring 2000	33.7	-
Fall 2000	-	-
Spring 2004	51.4	67.6
Fall 2004	48.2	62.6
Spring 2005	55.0	-
Average	**50.6**	**65.1**

1: Monitoring station 1ACAX004.57 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

5.2.2 Land Use

A comparison of land use distributions in the Popes Head Creek impaired watershed and Goose Creek reference watershed is provided in **Table 5-3**. Popes Head Creek and Upper Goose Creek watersheds are forested at 37% and 43%, respectively. The Upper Goose Creek watershed is composed of a higher percent of agricultural lands at 55% in comparison to Popes Head Creek watershed at 5%. Also, Popes Head Creek watershed has a higher percentage of urban land use at 57% in comparison to 2% in the Upper Goose Creek watershed. This difference in the percentage of urban land use is expected since the headwaters of Popes Head Creek flow through the western section of the City of Fairfax and the entire watershed is located within urban Fairfax County. It should be noted that the majority of the developed lands present in Popes Head Creek watershed are zoned for 2-acre and 4-acre lots which are comprised of less impervious surfaces those than typically observed in urban areas. Also, it is typically difficult to find an unimpaired reference watershed with a high percentage of urban land use. In addition, it is expected that the sediment loads from the more rural watershed will be balanced by the instream erosion load from the more urban watershed.

Table 5-3: Summary of Land Use Distributions for Popes Head Creek Impaired and Goose Creek Reference Watersheds

Land Use Category	% of Total Watershed	
	Popes Head	Goose Creek
Forest	37	43
Agricultural	4	55
Developed	58	2
Water/Wetlands	1	0
Barren	0	0
Total	**100**	**100**

5.2.3 Soils Distribution

A summary of the soils distribution for Popes Head impaired watershed and the Goose Creek reference watershed are provided in **Table 5-4**. Hydrologic soil groups represent the different levels of soil infiltration capacity. The soils distribution in Goose Creek reference watershed is similar to and representative of the soils distribution in Popes Head impaired watershed since the composition of the soils tends to have moderate infiltration rates (Hydrologic Group B).

Table 5-4: Summary of Soil Distributions for Popes Head Creek and Goose Creek

Hydrologic Group	% of Total Watershed	
	Popes Head	Goose Creek
A	3	0
B	69	83
C	9	16
D	16	1
C/D	3	0

6.0 Sediment Load Determination

A reference watershed approach was used to develop the sediment TMDL for the Popes Head Creek watershed as discussed in the previous section. The reference watershed identified for this impaired segment was the Goose Creek watershed above river mile 22.44 **(Figure 5-1)**. The sediment loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Popes Head Creek.

6.1 Sediment Source Assessment

Excessive sedimentation can adversely affect benthic invertebrate communities through the loss of habitat or food sources. Sediment can be delivered to the stream from point sources located in the watershed and it can be carried in the form of non-point source runoff from non-vegetated or protected land areas. In addition, sediment can be generated in the stream through the processes of scour and deposition which are primarily a function of stream flow. During periods of high flow, erosion of the stream channel occurs. The eroded materials are deposited downstream as stream flow decreases. These processes adversely impact the benthic macroinvertebrate community through loss of habitat and degradation of water quality.

Potential sediment sources within the Popes Head Creek watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Non-Point Sources

The erosion of land is dependent upon many factors including land use type and cover, soils type, and topography. The land use types in the Popes Head Creek watershed were characterized using NLCD and NVRC data, while soil types were characterized using the STATSGO database. The land use distribution for the Popes Head Creek watershed was previously shown in **Table 2-3** and a summary of soil types was provided in **Table 2-1**.

The delivery of eroded soils to the stream is primarily influenced by watershed size. Sediment loadings from generalized land use types present in the Popes Head Creek watershed are discussed below.

Forested Lands

Sediment loads from forested lands are typically low due to extensive root systems and vegetative cover that serve to stabilize soils. In addition, forest canopies intercept and dampen rainfall impacts.

Agricultural lands

Sediment loads from agricultural lands tend to be elevated due to the exposure of soil that occurs in agricultural practices. Cropland and pastureland are two sources of elevated sediment loads.

Developed Lands

Developed lands consist of both pervious and impervious surfaces. Impervious surfaces are not subject to soil erosion, but sediment loads may result from the washoff of solids deposited on impervious surfaces. Sediment loads from developed lands tend to be high. In addition, elevated levels of uncontrolled stormwater runoff from developed lands contribute to streambank erosion as discussed below.

Water/Wetlands

The amount of sediment loading from water and wetland areas typically is not significant.

Barren Lands

Transitional lands represent areas of sparse vegetative cover often due to land use activities such as forest clearcuts and construction lands. Due to increased levels of soil exposure, sediment loads from transitional lands typically are high.

6.1.2 Point Sources

Sediment loadings from point sources are attributable to the suspended solids present in discharge effluent. There are currently no permitted facilities holding active individual permits in the Popes Head Creek watershed. Municipal separate storm sewer systems (MS4s) transport storm water runoff that is ultimately discharged into local rivers and streams without treatment. The City of Fairfax, Fairfax County, Fairfax County Schools, and the VDOT urban areas are all covered by MS4 permits which regulate their stormwater discharges. Common pollutants from MS4s include oil and grease from roadways, pesticides from lawns, trash, and sediments. Combined, these MS4 permits cover approximately 98% of the Popes Head Creek benthic impairment watershed (**Table 6-2**). There are also a total of 7 general permits is within the watershed.

6.1.3 Instream Bank Erosion

Sediment derived from instream bank erosion is also dependent upon numerous watershed characteristics. Land use types present in the watershed may affect hydrology of the watershed. In particular, highly developed lands may lead to increased stream flows that erode the stream channel and banks. Likewise, watersheds defined by steep topography may experience high levels of runoff that cause instream erosion. The level of instream erosion is dependent on the erodibility of the soil, normally defined as the soil K factor. Since the Popes Head Creek benthic impairment watershed contains a significant percentage of developed lands, the overall amount of sediment generated by instream erosion would be expected to be high.

6.2 Technical Approach for Estimating Sediment Loads

6.2.1 Non-Point Source Sediment

For the purpose of TMDL development, annual sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model.

GWLF is a time variable simulation model that simulates hydrology and sediment loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Erosion and sediment loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. Sediment loadings from each source area are summed to obtain a watershed total. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a sediment delivery ratio is applied to determine the sediment loadings to the stream (USLE, Wischmeier and Smith, 1978), and is expressed as:

A =R K LS C P

Where:

A =Average annual soil loss in tons per acre per year

R =Rainfall/runoff erosivity

K =Soil erodibility

LS = Field slope length and steepness

C =Cover/management factor

P =Conservation practice factor

The R factor is an expression of the erosivity of rainfall and runoff in the area of interest; the R factor increases as the amount and intensity of rainfall increases. The K factor represents the inherent erodibility of the soils in the area of interest under standard experimental conditions. The K factor is expressed as a function of the particle-size distribution, organic-matter content, structure, and permeability of the soils. The LS factor represents the effect of topography, specifically field slope length and steepness, on rates of soil loss at a particular site. The LS factor increases as field slope length and steepness increase due to accumulation and acceleration of surface runoff as it flows in a downslope direction. The C factor represents the effects of surface cover and roughness, soil biomass, and soil-disturbing activities on rates of soil loss at the area of interest. The C factor decreases as surface cover and soil biomass increase. The P factor represents the effects of supporting conservation practices, such as contouring, buffer strips, and terracing, on soil loss at the area of interest.

6.2.2 Point Source Loadings

There are currently no individually permitted facilities in the Popes Head Creek impaired watershed. However, three permitted facilities are located in the reference watershed with permitted limits for TSS (**Table 6-1**). Additionally, stormwater sediment loads allocated to the general permits present in the watershed are presented in Appendix A.

Table 6-1: Point Sources in the Goose Creek Watershed with Permits for TSS

Facility Name	Permitted TSS Load (kg/day)	Annual Sediment Loading (ton/year)
Foxcroft School	0.6	0.25
Middleburg WWTP	2.7	1.1
Notre Dame Academy	0.1	0.05
Total	**3.5**	**1.4**

The MS4 permits state that the City of Fairfax, Fairfax County, Fairfax County Public Schools, and VDOT urban areas which hold MS4s are permitted to discharge into the Popes Head Creek impaired watershed. However, stormwater permits typically do not have numeric limits for sediment. To separate sediment loading attributed to the MS4s from other land-based sediment loading, an area weighted sediment load was determined for the MS4s, in which the percentage of sediment loading from each source area attributed to the MS4s was proportional to the percentage of that source area in the Popes Head Creek impaired watershed covered by the various MS4 permits. The MS4 areas located within the watershed are shown in **Table 6-2**. Additionally, stormwater runoff from MS4s results in increased stream bank erosion. Bank erosion resulting from MS4 stormwater runoff and bank erosion resulting from overland runoff were also separated using an area weighted approach, in which the percentage of sediment loading from bank erosion attributed to the MS4 was proportional to the percentage of the Popes Head Creek impaired watershed covered by the MS4 permits. Since 12,097.5 acres of the 12,120 total acres in the Popes Head Creek impaired watershed are covered by MS4 permits, 99.8 percent of the sediment load from instream erosion was attributed to the MS4s. Sediment from other land sources in the watershed and the remainder of the bank erosion sediment load were attributed to the land-based load.

Table 6-2: MS4 Permits located in Popes Head Creek Watershed

MS4 Permit Number	MS4 Permit Holder	MS4 Locality	Acres
VA0088587	Fairfax County	Fairfax County	11,926.0
VAR040104	Fairfax County Public Schools		
VAR040062	VDOT Urban Area		
VAR040064	City of Fairfax	City of Fairfax	171.5
VAR040062	VDOT Urban Area		
Total			**12,097.5**

6.2.3 Instream Erosion

Instream erosion in the Popes Head Creek was calculated using a spatial technique developed by Evans et al. (2003) that estimates streambank erosion based on watershed characteristics. Using this method, a watershed-specific lateral erosion rate is calculated as follows:

$$\text{LER} = aQ^{0.6}$$

Where:
LER = an estimated lateral erosion rate, expressed as meters per month
a = an empirically-derived “erosion potential factor”
Q = monthly stream flow, expressed as cubic meters per second.

The *'a'* factor is computed based on a wide variety of watershed parameters including the fraction of developed area of the watershed, average field slope, mean soil erodibility (K factor), average curve number value, and the mean livestock density for the watershed.

$$a = (0.00147*PD) + (0.000143*AD) + (0.000001*CN) + (0.000425*KF) + (0.000001*MS) - 0.00016$$

Where:
PD = fraction developed land
AD = animal density measured in animal equivalent units/acre
CN = area-weighted runoff curve number value
KF = area-weighted K factor
MS = mean field slope

The fraction of developed land in the Popes Head Creek watershed was obtained from NLCD data. The mean soil erodibility K factor and mean field slope of the watershed were computed from the STATSGO database. The average watershed curve number was developed based on curve numbers applied in the GWLF model. Livestock densities for the watershed were based on county livestock inventories. The 'a' factors for the Popes Head Creek watershed and Goose Creek Watershed were computed.

LER values were calculated using predicted stream flow from the GWLF model. Monthly sediment loads from streambank erosion (kg/month) were then calculated as the product of the LER (meters/month), total stream length (meters), average streambank height (meters), and average soil bulk density (kg/m^3). The total stream length for the Popes Head Creek was obtained from the National Hydrography Dataset (NHD). Bank height was estimated from field surveys of the Popes Head Creek. Mean soil bulk density was obtained from the STATSGO database. Annual sediment loads from streambank erosion were computed as the summation of monthly loads.

6.3 GWLF Model Setup and Calibration

6.3.1 GWLF Model Development

GWLF model simulations were performed for 1994 to 2004 in order to reflect the period of biomonitoring assessments that resulted in the impairment listing for the Popes Head Creek. In addition, the 10 year simulation period accounts for both seasonal and annual variations in hydrology and sediment loading. Models were developed for both the reference and impaired watersheds. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF that facilitates the creation of model input files and processing of model results.

As stated previously, under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Goose Creek watershed is larger than the Popes Head Creek impaired watershed, sediment loadings for the reference watershed were adjusted to reflect the size of the impaired watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed. In addition, instream erosion for the adjusted reference watershed was calculated using the total stream length of the impaired watershed.

6.3.2 Weather Data

Daily precipitation and temperature data were obtained from Upper Occoquan Sewage Authority (UOSA) and was used for model simulations. This weather station is located near the Popes Head Creek watershed and near Goose Creek, and thus provided the most accurate precipitation and temperature coverage for the watershed.

6.3.3 Model Input Parameters

In addition to weather data, GWLF requires specification of input parameters relating to hydrology, erosion, and sediment yield. In general, Appendix B of the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters.

Runoff curve numbers and USLE erosion factors are specified as an average value for a given source area. The NLCD land use types present in the watershed (Table 6-3) were used to define model source areas. Therefore, a total of 12 source areas were defined in the model. As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Table 6-3: Land Use Distribution Used in GWLF Model for the Popes Head Creek Watershed

General Land Use Category	Specific Land Use Type	Total Acres	Percent of Watershed	
Forested	Deciduous Forest	3,740	31%	38%
	Evergreen Forest	368	3%	
	Mixed Forest	474	4%	
Agriculture	Pasture/Hay/Livestock	373	3%	3%
	Row Crop	12	0%	
Developed	Low Intensity residential	5,035	42%	59%
	Commercial/Industrial	304	3%	
	Medium/High Residential	1,421	12%	
	Institutional	217	2%	
	Urban/Recreational Grass	162	1%	
Barren	Transitional	13	0%	0%
	Quarries/Strip Mine	0	0%	
Total		**12,120**	**100%**	**100%**

Runoff curve numbers were developed for each model source area in the watershed based on values published in the NRCS Technical Release 55 (NRCS, 1986). STATSGO soils GIS coverages were analyzed to determine the dominant soil hydrologic groups for each model source area. Evapotranspiration cover coefficients were developed based on values provided in the GWLF manual (Haith et al., 1992) for each model source area. Average watershed monthly evapotranspiration cover coefficients were computed based on an area weighted method. Initialization and groundwater hydrology parameters were set to default values recommended in the GWLF manual.

USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple sources based on data availability. Average KLSCP values for model source areas were determined based on GIS analysis of soils and topographic coverages and literature review. The rainfall erosivity coefficient was determined from values given in the GWLF manual. The sediment delivery ratio was computed directly in BasinSim.

Developed lands include impervious surfaces that are not subject to soil erosion. Rather, sediment loads from developed lands result from the buildup and washoff of solids deposited on the surface. Therefore, sediment loads from developed lands were not modeled using the USLE. Instead, sediment loads from developed lands were computed based on typical loading rates from developed lands (Horner et al., 1994).

6.3.4 Hydrology Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to be implemented without calibration. Nonetheless, comparisons were made between predicted and observed stream flow for the Popes Head Creek impaired and reference watersheds to ensure the general validity of the model.

The Occoquan Watershed Monitoring Laboratory (OWML) station ST40 located on Bull Run below the confluence with Popes Head Creek was selected for hydrology calibration based on the period of available monitoring data, its location in the watershed, and the proximity of the gage to the weather station used to develop the model precipitation inputs. **Figure 6-1** provides the location of the flow gage and weather station in relation to the Popes Head Creek watershed.

GWLF parameters relating to hydrology were calibrated based on the flow data collected at station ST40. The groundwater seepage coefficient and the unsaturated zone available water capacity were adjusted to obtain a best fit with observed data. Results of the hydrology calibration for impaired and reference watersheds are shown in **Figures 6-2** and **6-3**. **Table 6-4** shows the model calibration statistics. In general, model predictions reflect the flow variations observed at station ST40.

Table 6-4: Hydrology Calibration Statistics

Statistic	Bull Run Waterhsed	Goose Creek Watershed
R Squared (R^2)	**0.7**	**0.671**
% Error	**7%**	**2%**

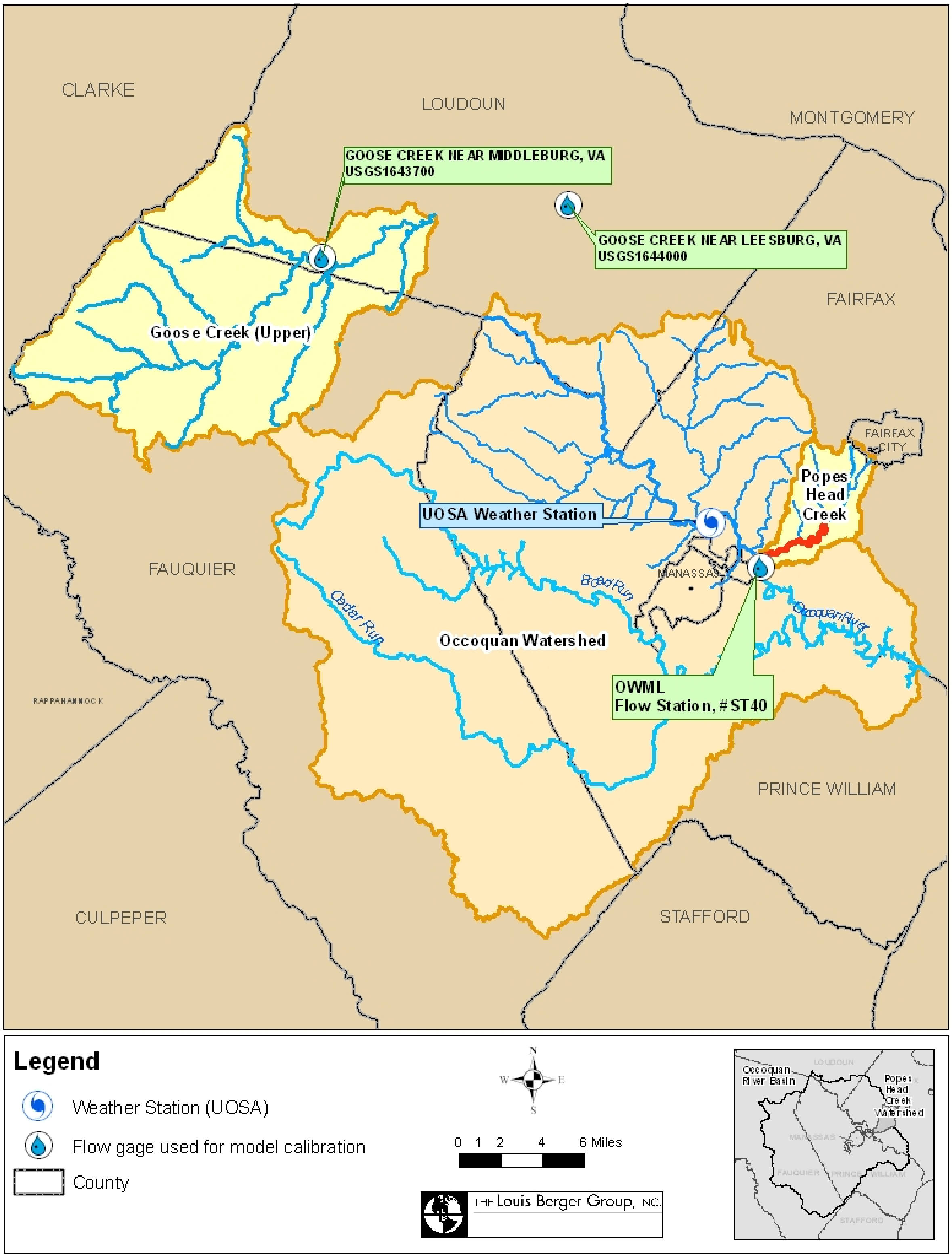

Figure 6-1: Flow and Weather Stations Used for Model Calibration

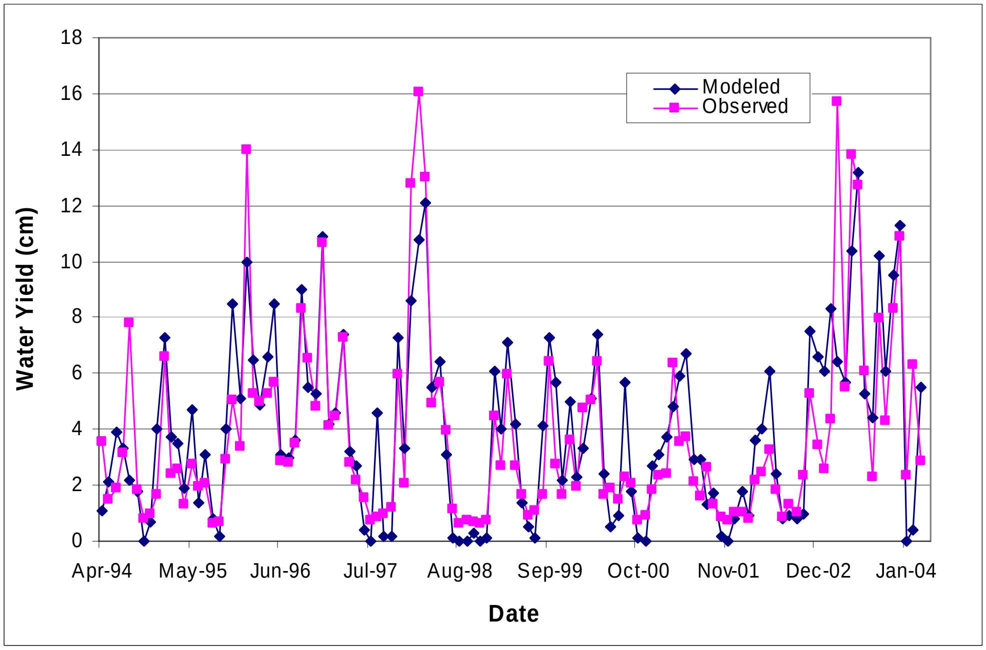

Figure 6-2: Hydrology Calibration Results for the Popes Head Watershed

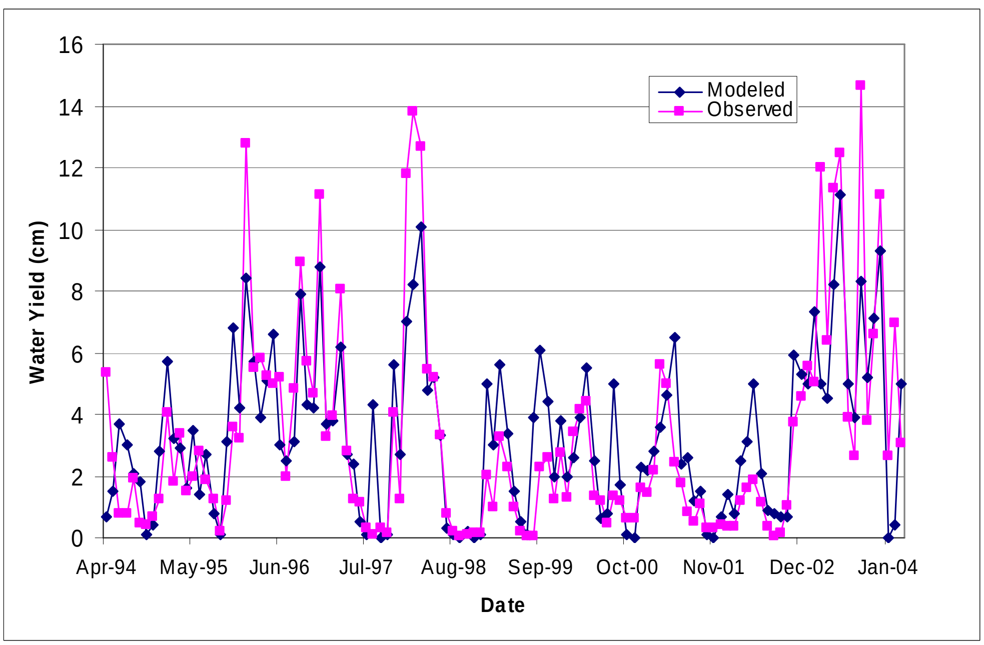

Figure 6-3: Hydrology Calibration Results for the Goose Creek Watershed

6.4 Sediment Load Estimates

6.4.1 Sediment Loads from Individual Permitted Facilities

Since, there are no individual permitted facilities located within the watershed, sediment loads are not attributed to any individual point source dischargers.

6.4.2 Sediment Loads from Non-Point Sources

The hydrologically calibrated model was used to estimate sediment loadings from each source area in the Popes Head Creek impaired and Goose Creek reference watersheds. Based on the 10 year simulation period from 1994 to 2004, average annual sediment loads were computed for each land source in each watershed. These results as the adjusted area weighted loads for the reference watershed are presented **Table 6-5.**

Table 6-5: Popes Head Creek Average Annual Sediment Loads (tons/yr) from Land Sources

Source	Impaired Watershed	Reference Watershed	Adjusted Reference Watershed
Transitional	13.0	55.6	12.3
Quarries/Strip Mine	0.0	0.0	0.0
Deciduous Forest	28.2	107.2	23.6
Evergreen Forest	2.8	4.2	0.9
Mixed Forest	3.6	65.5	14.4
Pasture/Hay/Livestock	85.8	6,923.9	1,526.5
Row Crop	14.3	459.9	101.4
Low Intensity Residential	3.9	0.6	0.1
Commercial/Industrial	21.7	15.3	3.4
Medium/High Residential	45.9	0.2	0.0
Institutional	7.0	0.0	0.0
Urban/Recreational Grass	0.1	0.0	0.0
Total	**226.4**	**7,632.3**	**1,682.7**

6.4.3 Sediment Loads from Instream Erosion

Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003), as described in Section 6.2.3. The ‘a’ factor used in the streambank erosion equation was computed using watershed specific data for the impaired and reference watersheds. Computed 'a' factors and annual sediment loads from streambank erosion are presented in **Table 6-6**.

Table 6-6: Popes Head Creek Annual Instream Erosion Estimates

Watershed	Computed 'a' Factor	Instream Erosion (tons/yr)
Impaired Watershed	9.27E-04	1,982
Reference Watershed	8.14E-05	2,659
Reference Watershed (Area Adjusted)	8.14E-05	90

6.5 Existing Sediment Loadings – All Sources

In summary, average annual sediment loads for the Popes Head Creek impaired and reference watersheds were determined as follows:

- Erosion and sediment yield from land sources were modeled using GWLF.
- Instream bank erosion was computed based on the method described by Evans et al. (2003).
- Sediment loads from point sources were calculated based on the permitted total suspended solids loading rate for each facility. However, no individual permitted facilities are located within the Popes Head Creek Watershed.
- An area-weighted percentage of the land based and bank erosion sediment load was used to partition sediment loading attributed to the MS4s and sediment loading attributed to other sources.

Average annual sediment loads from all sources for the Popes Head Creek impaired and Goose Creek reference watersheds are summarized in **Table 6-7**. The total existing sediment load in the impaired watershed is 2,208.7 tons per year. The area-adjusted reference watershed load of 1,773.1 tons per year represents the TMDL endpoint. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for the Popes Head Creek.

Table 6-7: Popes Head Creek Average Annual Sediment Loadings (tons/yr)

Source	Impaired Watershed (tons/yr)	Reference Watershed (tons/yr)	Reference Watershed (Area Adjusted) (tons/yr)
Transitional	13	55.6	12.3
Quarries/Strip Mine	0.0	0.0	0.0
Deciduous Forest	28.2	107.2	23.6
Evergreen Forest	2.8	4.2	0.9
Mixed Forest	3.6	65.5	14.4
Pasture/Hay/Livestock	85.8	6,923.9	1,526.5
Row Crop	14.3	459.9	101.4
Low intensity residential	3.9	0.6	0.1
Commercial/Industrial	21.7	15.3	3.4
Medium/High Residential	45.9	0.2	0.0
Institutional	7.0	0.0	0.0
Urban/Recreational Grass	0.1	0.0	0.0
Instream Erosion	1,982.30	2,659.20	90.4
Point Sources (individual Permits)	0.0	1.4	1.4
Total	**2,208.70**	**10,291.50**	**1,773.1**

As stated previously, the existing sediment load in the Popes Head Creek impaired watershed was distributed between the existing MS4-permitted areas and other non-point sources using an area weighted method. The MS4 sediment loads shown in **Table 6-8** include the loads from individual MS4s permits for urban areas, and also loads from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, General Permits for Carwashes, and General Permits for Construction Sites.

Table 6-8: Existing Sediment Loading in the Popes Head Creek Attributed to the MS4s and other Non-Point Sources

<table>
<tr><th>MS4 Permit Number</th><th>MS4 Permit Holder</th><th>MS4 Locality</th><th>Acres</th><th>Instream Erosion (tons/year)</th><th>Land Based (tons/year)</th><th>Total Load (tons/year)</th></tr>
<tr><td>VA0088587</td><td>Fairfax County</td><td rowspan="3">Fairfax County</td><td rowspan="3">11,926.0</td><td rowspan="3">1,952.1</td><td rowspan="3">222.9</td><td rowspan="3">2,175.0</td></tr>
<tr><td>VAR040104</td><td>Fairfax County Public Schools</td></tr>
<tr><td>VAR040062</td><td>VDOT Urban Area</td></tr>
<tr><td>VAR040064</td><td>Fairfax City</td><td rowspan="2">Fairfax City</td><td rowspan="2">171.5</td><td rowspan="2">28.1</td><td rowspan="2">3.2</td><td rowspan="2">31.3</td></tr>
<tr><td>VAR040062</td><td>VDOT Urban Area</td></tr>
<tr><td colspan="3">Total</td><td>12,097.5</td><td>1,980.2</td><td>226.1</td><td>2,206.3</td></tr>
</table>

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Sediment was identified as the primary stressor to the benthic community in the Popes Head Creek impaired watershed and a reference watershed approach was used for TMDL development. The total average annual sediment loading for the area-adjusted reference watershed (**Table 6-7**) represents the TMDL endpoint for the Popes Head Creek impaired watershed. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Popes Head Creek.

7.1 Basis for TMDL Allocations

Sediment TMDL allocations for the Popes Head Creek impaired watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Area-Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for the Popes Head Creek to account for uncertainties in the methodologies used to determine sediment loadings.

7.1.2 Wasteload Allocation

Currently, there are no individually permitted facilities located within the watershed. Following DEQ guidance, waste load allocations in watersheds without permitted facilities should not be shown as zero. Rather, they should be represented in the TMDL, expressed in terms of "less than" a number equal to or smaller than 1% of the Total Maximum Daily Load to account for future growth and potential point sources within the watershed. For this TMDL a 1 percent of the total allocated MS4 load is set aside for future growth.

However, there are MS4 and general permits within the watershed. The City of Fairfax, Fairfax County, and Fairfax County Schools are covered by MS4 permits which are included in the wasteload allocations. As discussed in Section 6.0, land-based loads were allocated to the MS4s based on an area weighted method. **Table 7-1** presents the contribution of sediment from all permitted stormwater sources including stormwater regulated under the municipal separate storm sewer system (MS4) program as well as stormwater regulated under general VPDES permits for construction and industrial activities. As indicated in **Table 7-1,** a 27.7 percent reduction in land-based sources and instream erosion allocated to the MS4s is required to achieve the TMDL endpoint. Also, sediment loads and instream erosion attributed to MS4s must be reduced by 27.7% to meet this endpoint. Wasteload allocations were based on an equal percent reduction from controllable sources. Loads from forested lands within the MS4 areas are not subject to reduction.

Wasteload allocations for facilities in the watershed holding general stormwater permits are presented in Appendix A. The majority of the facilities holding general stormwater permits are located in areas covered by MS4 permits, and is thus included in the MS4 wasteload allocation. Appendix A also provides a finer breakdown of the wasteload allocation by providing specific wasteload allocations for each facility holding a general stormwater permit.

Table 7-1: MS4 Existing and Allocated Loads within the Pope's Head Creek Watershed (tons/year)

MS4 Permit Number	MS4 Permit Holder	MS4 Area	Existing Loads (tons/year)	Allocated Load (tons/year)	% Reduction
VA0088587	Fairfax County	Fairfax County	2,175.0	1,571.5	27.7
VAR040104	Fairfax County Public Schools				
VAR040062	VDOT Urban Area				
VAR040064	City of Fairfax	City of Fairfax	31.3	22.6	27.7
VAR040062	VDOT Urban Area				
Total			**2,206.3**	**1,594.1**	**27.7**

The MS4 sediment allocations shown in **Table 7-1** cover the entire MS4 urban areas, therefore include the loads from individual MS4s permits, and also load from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, and General Permits for Construction Permits and the transitional land use category. The existing and allocated loads for the construction permits were estimated based on the loads from the transitional land-use category. Therefore, the transitional land-use category is assumed to be entirely comprised of construction sites. **Table 7-2** presents the sediment wasteload allocation for the sources regulated under the industrial and construction VPDES general permits.

Table 7-2: Wasteload Allocation for General Permits*

Category	Number of Permits	Existing Load (tons/year)	Allocated Load (tons/year)
General Residences	3	0.14	0.14
Construction Sites/ Transitional Land-use category	4	13.14	9.46

*The breakdown by each individual permit and the assumptions used in the load allocations are shown in Appendix A

The wasteload allocation presented in **Table 7-3** includes regulated stormwater discharges from Phase I and Phase II MS4 regulated entities. Phase I MS4 operators include Fairfax County. Phase II MS4 entities include the City of Fairfax; Fairfax County Schools; and Virginia Department of Transportation, Northern Virginia Urban Area (VDOT Urban Area). As discussed in Section 6.0, land-based loads were allocated to the MS4 based on an area weighted method.

The MS4 wasteload allocation is aggregated and presented by locality. The allocation represents the allowable loadings from all MS4 entities contained within the jurisdictional area of the locality. Due to the spatial overlap between the MS4 entities and the resulting uncertainty of the appropriate operator of the system, the MS4 loads are aggregated in the TMDL. For instance, certain roads within a county are maintained by VDOT, some by the county, and some by private subdivisions. Thus, it was not practical to separate out individual allocations to each MS4 permit holder.

The wasteload allocation for all stormwater sources, including MS4, industrial, and construction stormwater is aggregated by category based on the type of VPDES permit. The wasteload allocation computed for each permit category (e.g. MS4, construction stormwater, mines/quarries) shall be allocated to the individual permit holders at the discretion of the permitting regulatory agency through the issuance of VPDES stormwater permits.

Table 7-3: Wasteload Allocation for MS4 Areas Excluding General Permits

MS4 Permit Number	MS4 Permit Holder	MS4 Locality	Existing Loads (tons/year)	Allocated Load (tons/year)
VA0088587	Fairfax County	Fairfax County	2,162.1	1,562.1
VAR040104	Fairfax County Public Schools			
VAR040062	VDOT Urban Area			
VAR040064	City of Fairfax	City of Fairfax	31.1	22.6
VAR040062	VDOT Urban Area			
Total			**2,193.2**	**1,584.7**

7.1.3 Load Allocation

Load allocations for non-point sources not covered under the MS4 permits were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 28.2%, the sediment TMDL endpoint is achieved. This reduction corresponds to a 27.75% overall reduction when including all land-based loads (e.g., forest has a zero percent reduction). The existing and allocated sediment loads for all sources in the Popes Head Creek impaired watershed are presented in **Table 7-4**. In addition, the necessary percent reduction is shown for each source.

Table 7-4: Summary of Existing and Allocated Sediment Loads for Popes Head Creek Watershed

Source	Land Use Type	Existing Load (tons/yr)	Allocated Load (tons/yr)	Percent Reduction
Nonpoint Source	Deciduous Forest	0.0300	0.0300	0.0
	Evergreen Forest	0.0030	0.0030	0.0
	Mixed Forest	0.0038	0.0038	0.0
	Pasture/Hay	0.0914	0.0656	28.2
	Row Crop	0.0153	0.0110	28.2
	Quarries Strip Mine	0.0000	0.0000	0.0
	Low Intensity Residential	0.0041	0.0030	28.2
	Medium High Intensity	0.0489	0.0351	28.2
	Commercial/Industrial	0.0232	0.0166	28.2
	Institutional	0.0075	0.0054	28.2
	Urban Recreational Grass	0.0001	0.0001	28.2
	Instream Erosion	2.1115	1.5163	28.2
Permitted Facilities	Individual VPDES Permits	0.0	15.8*	0.0
	General Permits-Domestic Sewage	0.1369	0.1369	0
	Stormwater Permits-Construction	13.14	9.46	28.2
MS4	Nonpoint Source	224.79	160.8#	28.42#
	Instream Erosion	1,968.39	1,408.0#	28.47#
	Total	**2,208.8**	**1,596.0**	**27.75**

(*)A one percent (1%) of the MS4s allocated loads (NPS + instream erosion) was set aside to account for future growth and the potential change in land-use from rural/open space to urban.
(#) the MS4 loads (NPS and instream erosion) are reduced by 15.8 tons/year (1% set aside to accommodate for future growth) in order to met the TMDL target

7.2 Overall Recommended TMDL Allocations

The total load and wasteload allocations and margin of safety for the Popes Head Creek are summarized in **Table 7-5**. Recommended allocations for each source in the watershed are provided in **Table 7-4**. For this TMDL a 1 percent of the total allocated MS4 load (15.8 tons/year) is set aside for future growth.

Table 7-5: Sediment TMDL for Popes Head Creek (tons/year)

TMDL (tons/yr)	Load Allocation (tons/yr)	Wasteload Allocation (Point Source + MS4s) (tons/yr)	Margin of Safety (10%) (tons/yr)
1,773.1	**1.7**	**1594.2**	**177.3**

7.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of the Popes Head Creek, the primary stressor resulting in the benthic impairment in the river is excessive sediment loading, which has led to siltation and the loss of benthic habitat. On an average annual basis, land-based sources and in-stream erosion account for 100% of the total sediment load to the stream; this includes non-point source loading, and loading attributed to the MS4s present in the watershed. Therefore, most of the sediment load is delivered under high flow conditions associated with stormwater runoff.

Since sediment loading occurs throughout the year, primarily due to land-based runoff, and its impacts on benthic invertebrates are often a function of cumulative loading, it is appropriate to consider sediment loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 10 year simulation period performed using the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and sediment loading by using a daily time-step for water balance calculations. Therefore, the 10 year simulation performed with GWLF adequately captures seasonal variations.

8.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and non point sources in the stream (see section 7.4.2). For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA pursuant to 40 CFR '122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

8.1 Staged Implementation

In general, Virginia intends for the required BMPs to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;

2. It provides a measure of quality control, given the uncertainties inherent in

computer simulation modeling;

3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;

4. It helps ensure that the most cost effective practices are implemented first; and

5. It allows for the evaluation of the adequacy of the TMDL in achieving water

quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

8.2 Stage 1 Scenarios

The TMDL allocation scenario to reduce sediment loading to the Popes Head Creek was presented in Section 7.0. Under this scenario, the sediment TMDL endpoint is achieved by reducing sediment loads from agricultural, transitional, developed lands and instream erosion by 28.2%. Also, sediment loads and instream erosion attributed to MS4s must be reduced by approximately 28.47% to meet this scenario. Allocated sediment loads and the percent reduction required for all watershed sources are presented in **Table 8-1**.

Table 8-1: Summary of Existing and Allocated Sediment Loads for Popes Head Creek Watershed

Source	Land Use Type	Existing Load (tons/yr)	Allocated Load (tons/yr)	Percent Reduction
Nonpoint Source	Deciduous Forest	0.0300	0.0300	0.0
	Evergreen Forest	0.0030	0.0030	0.0
	Mixed Forest	0.0038	0.0038	0.0
	Pasture/Hay	0.0914	0.0656	28.2
	Row Crop	0.0153	0.0110	28.2
	Quarries Strip Mine	0.0000	0.0000	0.0
	Low Intensity Residential	0.0041	0.0030	28.2
	Medium High Intensity	0.0489	0.0351	28.2
	Commercial/Industrial	0.0232	0.0166	28.2
	Institutional	0.0075	0.0054	28.2
	Urban Recreational Grass	0.0001	0.0001	28.2
	Instream Erosion	2.1115	1.5163	28.2
Permitted Facilities	Individual VPDES Permits	0.0	15.8*	0.0
	General Permits-Domestic Sewage	0.1369	0.1369	0
	Stormwater Permits-Construction	13.14	9.46	28.2
MS4	Nonpoint Source	224.79	160.8#	28.42#
	Instream Erosion	1,968.39	1,408.0#	28.47#
	Total	**2,208.8**	**1,596.0**	**27.75**

(*)A one percent (1%) of the MS4s allocated loads (NPS + instream erosion) was set aside to account for future growth and the potential change in land-use from rural/open space to urban.
(#) the MS4 loads (NPS and instream erosion) are reduced by 15.8 tons/year (1% set aside to accommodate for future growth) in order to met the TMDL target

8.3 Overall Recommended TMD Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Chesapeake Bay. Several BMPs known to be effective in controlling sediment have also been identified for implementation as part of the Tributary Strategy for the Potomac River Basin. Examples of sediment pollution reduction practices include:

- Agricultural Best Management Practices (BMP) includes practices to reduce or eliminate soil loss, prevent runoff, and provide for the proper application rates of nutrients to cropland, vegetated buffer strips at the edge of crop fields, conservation tillage, strip cropping, animal waste management, and stream bank fencing

- Urban Best Management Practices which include erosion and sediment BMPs to control runoff from areas under development and stormwater controls in developed areas. These practices are applied across a broad spectrum from industrial, commercial, and residential facility construction sites to the management of lawns and open spaces, reducing nutrient runoff.
- Stormwater Management controls including Low Impact Development (LID)
- Upgrades made to wastewater treatment plants, many which are performed during the installation of biological nutrient removal (BNR) process to meet Bay nutrients allocations
- Septic system maintenance
- Stream Buffers. Streamside forest to reduce or remove excess nutrients and sediment from surface runoff and shallow groundwater and aid in shading streams to optimize light and temperature conditions for aquatic plants and animals.

Fairfax County is in the process of developing watershed management plans countywide, and the plan for Popes Head Creek was completed in October 2005 and approved by the Board of Supervisors in January 2006. The Popes Head Creek Watershed Management Plan was developed with the help of a citizens' advisory committee and other public input, and it lays out the county's strategy for improving stormwater management in the watershed over the next 25 years. The plan includes proposed projects throughout the watershed that fall into the following categories: debris and obstruction removal, stormwater management pond retrofits, low impact development practices, bridge and culvert replacements and retrofits, and stream restoration projects. The plan also includes non-structural projects such as public education and outreach, monitoring, and proposed policy changes. The recommendations made in the Popes Head Creek Watershed Management Plan will be considered during the implementation planning process for this TMDL and incorporated as appropriate.

8.3.1 Follow-Up Monitoring

Following the development of the TMDL, the Department of Environmental Quality (DEQ) will make every effort to continue to monitor the impaired stream in accordance with its ambient and biological monitoring programs. DEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. In accordance with DEQ Guidance Memo No. 03-2004, during periods of reduced resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. Monitoring can resume at the start of the following fiscal year, next scheduled monitoring station rotation, or where deemed necessary by the regional office or TMDL staff, as a new special study. Since there may be a lag time of one-to-several years before any improvement in the benthic community will be evident, follow-up biological monitoring may not have to occur in the fiscal year immediately following the implementation of control measures.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year.

DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the IP), the effectiveness of the TMDL in attaining and maintaining water quality standards, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by citizens' or watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with DEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or Implementation plan has been completed), DEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

8.3.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. EPA also requires that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). All such permits should be submitted to EPA for review.

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 “Guidance for Water Quality-Based Decisions: The TMDL Process.” The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL’s LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed. An exception are the municipal separate storm sewer systems (MS4s) which are both covered by NPDES permits and expected to be included in TMDL implementation plans, as described in the stormwater permit section below.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the state’s Water Quality Management Plans. The WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as is the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf.

8.3.3 Stormwater Permits

DEQ and DCR coordinate separate State programs that regulate the management of pollutants carried by storm water runoff. DEQ regulates storm water discharges associated with "industrial activities", while DCR regulates storm water discharges from construction sites, and from municipal separate storm sewer systems (MS4s).

EPA approved DCR's VPDES storm water program on December 30, 2004. DCR's regulations became effective on January 29, 2005. DEQ is no longer the regulatory agency responsible for administration and enforcement of the VPDES MS4 and construction storm water permitting programs. More information is available on DCR's web site through the following link: http://www.dcr.virginia.gov/sw/vsmp

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is DCR's Virginia Stormwater Management Program (VSMP) Permit Regulation (4 VAC 50-60-10 et. seq). Section 4VAC 50-60-380 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that NPDES permit conditions may consist of "Best management practices to control or abate the discharge of pollutants when:…(2) Numeric effluent limitations are infeasible,…".

Part of the Popes Head Creek watershed is covered by MS4s for small municipal separate storm sewer systems (MS4s) owned by the County of Fairfax, the City of Fairfax, the County of Fairfax Public Schools, and the Virginia Department of Transportation. The permits state, under Part II.A., that the "permittee must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law."

The permit also contains a TMDL clause that states: "If a TMDL is approved for any waterbody into which the small MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of stormwater discharges. If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Stormwater Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." ("Board" means the Soil and Water Conservation Board)

For MS4/VSMP general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations for stormwater through the implementation of programmatic BMPs. BMP effectiveness would be determined through ambient in-stream monitoring. This is in accordance with recent EPA guidance (EPA Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002). If future monitoring indicates no improvement in stream water quality, the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation. However, only failing to implement the programmatic BMPs identified in the modified stormwater management program would be considered a violation of the permit. Any changes to the TMDL resulting from water quality standards changes on Popes Head Creek would be reflected in the permit.

Wasteload allocations for stormwater discharges from storm sewer systems covered by a MS4 permit will be addressed in TMDL implementation plans. An implementation plan will identify types of corrective actions and strategies to obtain the wasteload allocation for the pollutant causing the water quality impairment. Permittees need to participate in the development of TMDL implementation plans since recommendations from the process may result in modifications to the stormwater management plan in order to meet the TMDL.

Additional information on Virginia's Stormwater Phase 2 program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/sw/vsmp.htm .

8.3.4 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

8.3.5 Attainability of Designated Uses

In some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use.

In order for a stream to be assigned a new designated use, the current designated use must be removed. To remove a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of the contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/WQS03AUG.pdf

The process to address potentially unattainable reductions based on the above is as follows: First is the development of a stage 1 scenario such as those presented previously in this chapter. The pollutant reductions in the stage 1 scenario are targeted only at the controllable, anthropogenic sources identified in the TMDL. During the implementation of the stage 1 scenario, all controllable sources would be reduced to the maximum extent practicable using the iterative approach described in Section 8.2 above. DEQ will re-assess water quality in the stream during and subsequent to the implementation of the stage 1 scenario to determine if the water quality standard is attained. This effort will also evaluate if the modeling assumptions were correct. If water quality standards are not being met, and no additional cost-effective and reasonable best management practices can be identified, a UAA may be initiated with the goal of re-designating the stream for a more appropriate use.

9.0 Public Participation

The development of the Popes Head Creek benthic TMDL would not have been possible without public participation. Three technical advisory committee (TAC) meetings and three public meetings were held. The following is a summary of the meetings.

TAC Meeting No. 1. The first TAC meeting was held on March 1, 2005 at the DEQ office in Woodbridge to present and review the steps and the data used in the development of the benthic TMDLs for the Popes Head Creek listed segment.

TAC Meeting No. 2. The second TAC meeting was held on November 3, 2005 at the DEQ office in Woodbridge, VA to discuss the preliminary benthic stressors identified for Popes Head Creek.

TAC Meeting No. 3. The third TAC was held on March 1, 2006 at the DEQ office in Woodbridge VA to discuss the completed TMDL for Popes Head Creek's benthic impairment.

Public Meeting No. 1. The first public meetings were held in on March 30, 2005 at the Sully District Governmental Center in Chantilly, Virginia and on April 5, 2005 at the Pennington School in Manassas, Virginia to present the process for TMDL development, the Popes Head Creek benthic impaired segment, data that caused the segment to be on the 303(d) list, data and information needed for TMDL development, and preliminary findings regarding potential stressors. Nineteen people attended this meeting. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register*. No written comments were received during the 30-day comment period.

Public Meeting No. 2. The second public meeting was held in on December 14, 2005 at the Sully District Governmental Center in Chantilly, Virginia to discuss the preliminary benthic stressors identified for Popes Head Creek. Six people attended this meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

Public Meeting No. 3. The third public meeting on the development of the Occoquan Basin Streams TMDLs was held on March 15, 2006 at the. Central Community Library in Manassas, VA to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft TMDL. Ten people attended this meeting. Copies of the presentation and the draft TMDL report executive summary was available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

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APPENDIX A: General Permit & Individual Permit Stormwater TMDL Allocations

The TSS allocation for each permitted facility was calculated using a DEQ assigned TSS concentration and the corresponding runoff amount generated on the site based on the facility area or the facility discharge. The TSS allocated load for each permit type was calculated as follows:

- For general permits issued to domestic sewage facilities, the allocated load was calculated based on a TSS concentration of 30 mg/L and a discharge flow value of 1,000 gpd (**Table A-1**).

$$Q_{general\ permit}(tons/year) = 1{,}000\frac{gallons}{day}\ x\ \frac{3.785\,liter}{gallon}\ x\ \frac{365\,day}{yr}\ x\ \frac{30\,mg}{liter}\ x\ \frac{kg}{10^6\,mg}\ x\ \frac{2.204\,lbs}{kg}\ x\ \frac{ton}{2000\,lbs}$$

- For general stormwater permits issued to construction sites, the total allocated load was calculated based on the allocated loads from the transitional land-use category. In other words, transitional land use was considered as representing the construction activities within the watershed (**Table A-2**).

Table A-1: TMDL Allocations for General Permits Issued to Domestic Sewage Facilities

Permit	Facility	Receiving Stream	TSS (tons/yr)
VAG406296	Residence	Piney Branch UT	0.046
VAG406202	Residence	Piney Branch, UT	0.046
VAG406252	Residence	Pope's Head Creek, UT	0.046

Table A-2: TMDL Allocations for Construction Sites

Land Use Type	Disturbed Acres	Allocated load (tons/year)
Transitional	13.14	9.46